WSDOT MITIGATION SITES
OLYMPIC REGION

2004 MONITORING REPORT

Wetland Assessment and Monitoring Program

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Olympic Region 2004 Annual Monitoring Report

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Executive Summary

This report documents the status of the Olympic Region mitigation sites (Map 1.1) with respect to success standards for 2004. The following tables summarize performance criteria and results obtained in 2004.

Site Name	Performance Criteria	2004 Results
SR 12 Black River		
	Hydrology present at least 12.5% of the growing season (consecutive)	Present
	Less than 20% reed canarygrass or other invasive species	23% ($CI_{80\%}$= 19% - 27% cover)
SR 7 Nisqually Slough		
	Less than 20% reed canarygrass or invasives in wetland or buffer	Wetland: 3% ($CI_{80\%}$ = 0% - 5% cover) Buffer: 10% ($CI_{80\%}$ = 8% - 13% cover)
	Wetland hydrology 12.5% growing season	Present
	At least 70% cover by grasses and forbs	95% ($CI_{99\%}$ = 92% - 98% cover)
SR 161 Kapowsin		
	Hydrology at least 12.5% of growing season	Present
	Less than 20% invasive species	7% ($CI_{80\%}$ = 5% - 9% cover)
SR 509 Erdahl Ditch		
	Create 0.44 acres of wetland	0.46 acres created
	$\geq$ 80% aerial cover of woody species in the buffer	95% ($CI_{99\%}$ = 89% - 100% cover)
	$\geq$ 90% aerial cover by FAC or wetter species in the wetland	93% ($CI_{90\%}$ = 84% - 100% cover)
	Presence of wetland-dependent species	Yes
	$\geq$ 90% aerial cover by vegetation in wetland	99% ($CI_{99\%}$ = 95% - 100% cover)
	2:1 grade minimum and dense buffer vegetation	Present
	Less than 10% cover of non-invasive species	19% ($CI_{80\%}$ = 16% - 24% cover)

List of Acronyms

Acronym	Meaning
CI	Confidence Interval (see Methods and Glossary)
ECY	Washington State Department of Ecology
FAC	Facultative Indicator Status (see Glossary and Reed 1988)
FACW	Facultative Wetland Indicator Status (see Glossary and Reed 1988)
IP	Individual Permit
MP	Mile Post
NWP	Nationwide Permit
OBL	Obligate Wetland Indicator Status (see Glossary and Reed 1988)
SR	State Route
USACE	United States Army Corps of Engineers
WDFW	Washington Department of Fish and Wildlife
WSDOF	Washington Department of Fisheries
WSDOT	Washington State Department of Transportation

Introduction

Infrastructure improvements including highway construction projects, highway interchanges, and bridges have accompanied economic and population growth in the state of Washington. The Washington State Department of Transportation (WSDOT) evaluates the potential for degradation of critical areas that may result from these infrastructure improvements. WSDOT strictly complies with applicable federal, state, and local environmental regulations, including the Clean Water Act and the state "no net loss" policy for wetlands (Executive Order 89-10). Generally, mitigation sites are planned when transportation improvement projects adversely affect critical and/or sensitive areas. The WSDOT Wetland Assessment and Monitoring Program monitors these mitigation sites as a means of evaluating compliance with permit conditions and tracking site development.

The purpose of this document is to report the status of Olympic Region WSDOT mitigation sites with respect to permit compliance and success standards for 2004 (Map 1.1). Following a general description of our process and methods, this report presents 2004 monitoring results for mitigation sites in this region. Site reports are organized by county and state route number.

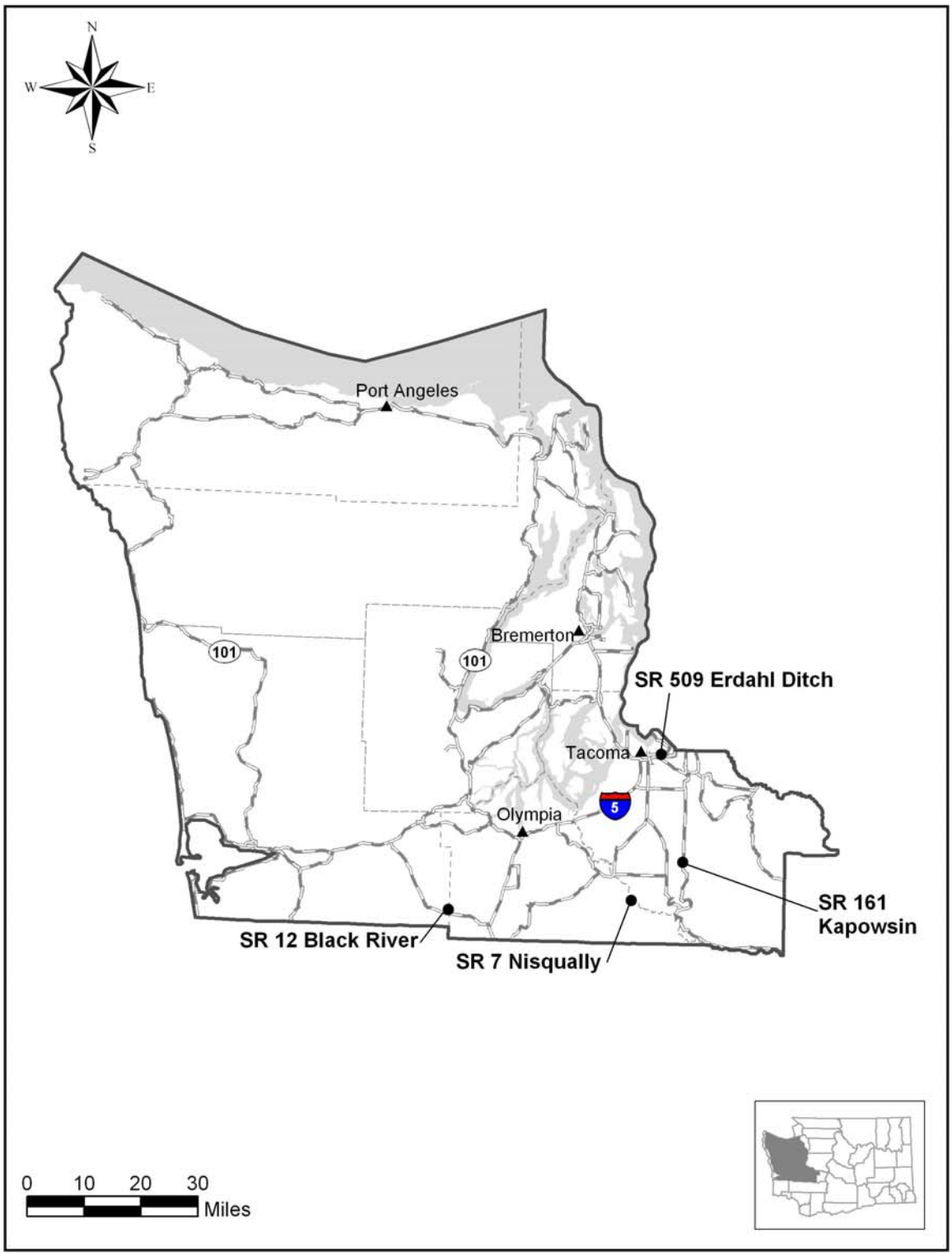
Process

Monitoring typically begins the first spring after a site is planted and continues for the time period designated by the permit or mitigation plan. The monitoring period generally ranges from three to ten years. In special cases sites may be monitored beyond the designated monitoring period.

Monitoring activities are driven by site-specific success standards detailed in the mitigation plan or permits. Data are collected on a variety of environmental parameters including vegetation, soils, hydrology, and wildlife. When data analysis is complete, information on site development is communicated to region staff to facilitate management activities as part of an adaptive management process. Monitoring reports are issued to regulatory agencies and published on the web at:

http://www.wsdot.wa.gov/environment/wetmon/MonitorRpts.htm

Map 1.1 Olympic Region Mitigation Site Locations



Methods

Methods used for monitoring mitigation sites change as site requirements and customer needs evolve. Quantitative data collection techniques presently in use are based on standard ecological and biostatistical methods.[1] The Wetland Program's current monitoring methods include the following key elements:

Objective-based Monitoring

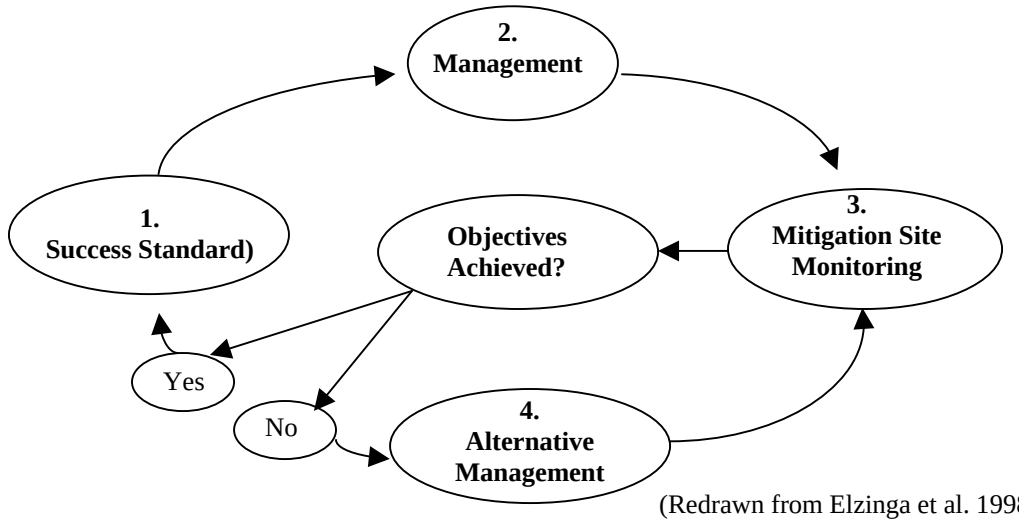
We collect data using a monitoring plan and sampling design developed specifically for each site. The monitoring plan and sampling design address success standards, permit requirements, contingencies, and other considerations as appropriate.

Adaptive Management

The adaptive management process includes four iterative steps:

1. success standards are developed to describe the desired condition,
2. management action is carried out to meet the success standard,
3. the response of the resource is monitored to determine if the success standard has been met, and
4. management is adapted if the standards are not achieved.

Monitoring is integral to the success of an effective adaptive management strategy. Without valid monitoring data, management actions may or may not result in improved conditions or compliance with regulatory permits. Timely decisions, based on valid monitoring data, result in increased efficiency and higher probabilities of success (Shabman 1995; Thom and Wellman 1996). The adaptive management process is illustrated in Figure 2.1.



(Redrawn from Elzinga et al. 1998)

Figure 2.1 The Adaptive Management Process

[1] These methods are based on techniques described in Bonham (1989), Elzinga et al. (1998), Krebs (1999), Zar (1999), and other sources.

Data Collection and Analysis

WSDOT's monitoring approach strives to minimize subjectivity in data collection and increase the reliability of data collection and analysis. Important considerations include appropriate sampling design, sampling resolution, random sampling procedures, interspersion and independence of sample units, and sample size analysis. Our goal is to provide WSDOT and regulators with an objective evaluation of site conditions based on valid and reliable monitoring data.

Success Standards and Sampling Objectives

Success standards (or performance standards) are important elements of a mitigation plan. They indicate the desired state or condition of the mitigation site at a given point in time. Conditional permit requirements, if different from success standards in the mitigation plan, are also evaluated during monitoring activities. Some mitigation plans also provide contingencies if a specific undesirable condition occurs. Contingencies typically initiate a management response at the onset of a particular condition, for example, excessive cover by invasive species or insufficient cover by trees and shrubs.

Wetland Assessment and Monitoring Program staff thoroughly examine success standards and permit requirements to understand the desired site condition or characteristics to be measured. Six elements are sought in relation to each success standard to ensure measurability of the desired condition: species indicator, location, attribute, action, quantity/status, and time frame. Where one or more of the six elements is undocumented or unclear in the mitigation plan or permit, clarification is sought from region staff.

Success standards are copied verbatim from the mitigation plan in the success standards and sampling objectives section of each site report. Differences in common usage of the terms *aerial* and *areal* has made their interpretation in mitigation plans difficult. We feel that the term aerial better describes the intent of the mitigation plans in most cases. Where we judge the word *areal* has been used arbitrarily in the success standards, we follow it with a (*sic*) notation. The Glossary defines the meaning of these words as used in this document.

Sampling may be required to address success standards unless an efficient and reliable total accounting of the target attribute can be conducted. Sampling objectives are developed to guide the data collection process. Sampling objectives include a confidence level and confidence interval half width.

The results of sampling are presented with the confidence level and confidence interval noted as ($CI_X = Y_1$-Y_2), where CI = confidence interval, X = confidence level, and confidence interval width is expressed as Y_1 low estimate to Y_2 high estimate. For example, an estimated aerial cover provided by woody species reported as 65% ($CI_{80\%}$ = 52-78% cover) means that we are 80% confident that the true aerial cover value is between 52% and 78% (Figure 2.2).

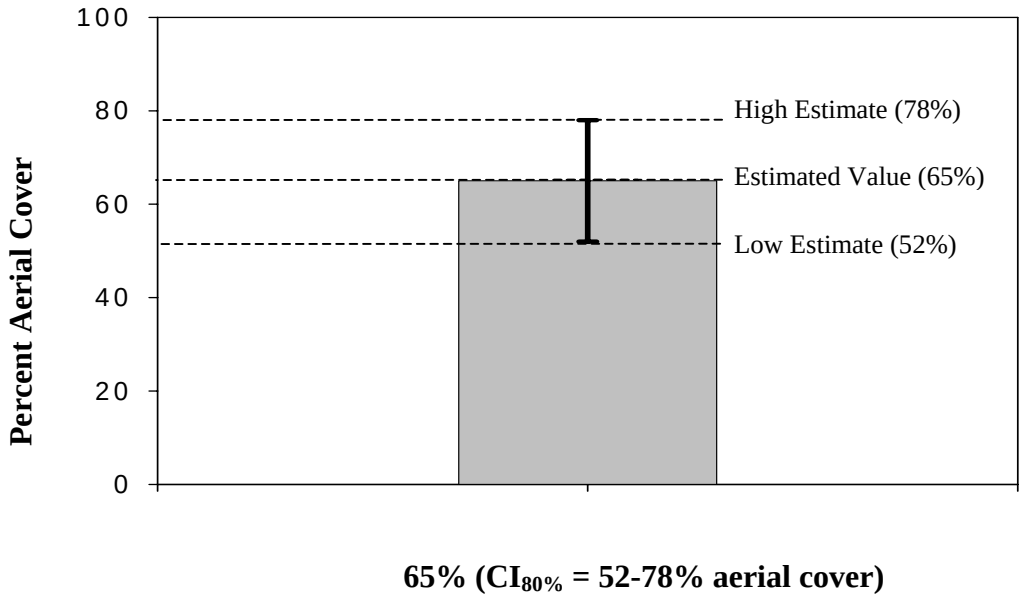


Figure 2.2 Estimated Cover Value Expressed with Confidence Interval Range

For compliance purposes, aerial cover calculations include only areas covered by rooted vascular plants (including floating-leaved species). Areas covered by thallophytes (algae, fungi, bacteria), bryophytes (mosses and liverworts), structures, or non-rooted aquatic vegetation are not included in aerial cover calculations. Scientific names, most common names, and nativity used in this report were obtained from the *PLANTS Database* (USDA 2003 (http://plants.usda.gov)). Hydrophytic plant indicator status was obtained from the *National List of Plant Species that Occur in Wetlands: Northwest* (Reed 1988 and 1993). Where noxious weeds are addressed, county specific listings in the *State Noxious Weed List* are referenced (Washington State Noxious Weed Control Board 2004 www.nwcb.wa.gov).[2]

Sampling Design

When sampling is required, a sampling design is developed for the site or zone of interest. Sampling designs can vary from simple to complex depending on the number and type of attributes to be measured. Specific elements such as the size and shape of the site, the presence of environmental gradients, plant distribution patterns, and the amount of time and resources available for monitoring are factors that influence the sampling design. Additional elements typically include the location of the baseline, orientating transects parallel to the primary environmental gradient, the method of data collection, and the number and type of sample units to be used. Depending on the sampling objective and site characteristics, transects may vary in number, length, and separation distance. Sampling transect locations are determined by using either a simple, systematic, stratified, or restricted random sampling method. A diagram showing the sampling design is typically included in mitigation site reports (Figure 2.3).

[2]In some cases, other nuisance species may be included in invasive cover estimates.

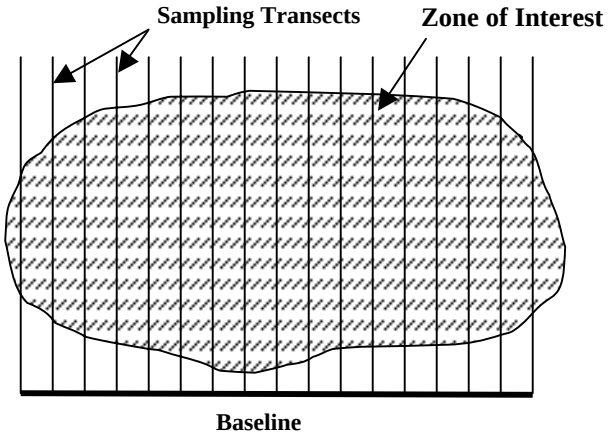


Figure 2.3 Baseline and Sampling Transects

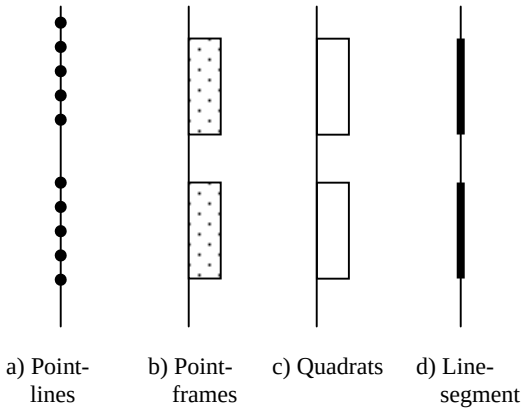


Figure 2.4 (a-d) Sampling Transects and Sample Units

Sample units appropriate to one or more of the methods described below are randomly located on or adjacent to the sampling transects (Figure 2.4 a-d). These figures are general representations of the actual sampling designs and do not include specific details. Typically, point-lines and point-frames are used to collect herbaceous cover data, quadrats are used to estimate survival and density, and line-segments are used to estimate woody cover.

Point-Line Method

To estimate cover by herbaceous and/or woody species, sample units consisting of a fixed set of points (point-lines) are randomly located along sampling transects (Bonham 1989; Elzinga et al. 1998) (Figure 2.4a). Tools used to collect point-line data include point-intercept devices, pin flags, or densitometers. These tools are used to identify point locations. Target vegetation intercepted by the point locator is recorded. If target species are not encountered on the point; bare soil, non-vascular plant, or habitat structure is recorded as appropriate. For each sample unit, cover is determined based on the number of times target vegetation is encountered divided by the total number of points. For example, if invasive species were encountered on 20 points from a sample unit composed of 100 points, the aerial cover of invasive species for that sample unit is 20%.[3]

Point-Frame Method

To estimate cover by herbaceous species, point-frames are randomly located along sampling transects (Bonham 1989; Elzinga et al. 1998). A point-frame is a rectangular frame that encloses a set of points collectively serving as a sample unit (Figure 2.4b).[4] The point frame is lowered over herbaceous vegetation and data is recorded where target vegetation intercepts point locations. As with the point-line method, a cover value for each sample unit is determined. For example, if facultative-wetland (FACW) and obligate (OBL) species were encountered on 20 points in a point-

[3] Aerial cover is calculated allowing only one "hit" of target vegetation per point. In this example, two invasive plants encountered at the same point would constitute one "hit." Aerial cover may not exceed 100%.

[4] The WSDOT Wetland Assessment and Monitoring Program typically uses a frame formed with polyvinyl chloride (PVC) pipe. Strings span the frame lengthwise and points are marked on the strings using a standard randomization method.

frame composed of 40 points, the aerial cover of FACW and OBL species for that point-frame sample unit is 50%.

Quadrat Method

To estimate survival or density of woody species in an area, quadrat sample units are randomly located along sampling transects (Bonham 1989; Elzinga et al. 1998). Quadrat width and length are based on characteristics of the target plant community and its pattern of distribution. Quadrats are typically located lengthwise along sampling transects (Figure 2.4c). Target plants within a quadrat are recorded as alive, stressed or dead. The success standard or contingency threshold can be addressed with a percent survival estimate of plantings, or a density per unit area of living plantings as appropriate. For example, if eight planted woody species were recorded as alive and two were recorded as dead in a sample unit measuring 1 x 20 meters, the survival of planted woody species for that sample unit would be 80%, and the density would be 0.4 live plants per square meter.

Line-Intercept Method

Cover data for the woody species community is collected using the line-intercept method (Bonham 1989; Elzinga et al. 1998).[5] Line-segments, serving as sample units, are randomly located along sampling transects (Figure 2.4d). All woody vegetation intercepting the sample unit is identified and the length of each canopy intercept recorded.[6] To calculate an aerial cover value for each sample unit, the sum of the canopy intercept lengths is divided by the sample unit length. For example, if woody vegetation was encountered on 80 meters from a 100-meter sample unit, the aerial cover for that sample unit is 80%.

Sample Size Analysis

With each of the above methods, sample size analysis is performed in the field to ensure that an adequate number of sample units are obtained to report the data at the specified confidence level and interval. The sample mean and sample standard deviation are calculated from the data, and sample size analysis is conducted.

The sample size is evaluated using the following equation for estimating a single population mean or a population total within a specified level of precision (Elzinga et al. 1998). A sample size correction to n is necessary for adjusting "point-in-time" parameter estimates.[7] The adjusted n value identifies the number of sample units required to report the estimated mean value at a specified level of confidence.

$$n = \frac{(z)^2 (s)^2}{(B)^2}$$

z = standard normal deviate
s = sample standard deviation
B = precision level[8]
n = unadjusted sample size

[5] Depending on site conditions and other considerations, woody cover data may be collected using the point-line method and a densitometer.

[6] Two or more plants may cover the same length of the sample unit. Overlap is removed from the data before calculating the aerial cover. Aerial cover may not exceed 100%.

[7] Adjusted n values found in this report were obtained using the algorithm for a one-sample tolerance probability of 0.90 (Kupper and Hafner 1989; Elzinga et al 1998).

[8] In this equation, the precision level equals half the maximum acceptable confidence interval width multiplied by the sample mean.

Wildlife Monitoring

Many mitigation plans include goals and objectives that address wildlife. For these sites, incidental wildlife observations are obtained to provide information to support the results of the vegetation monitoring.

Bird Monitoring

Some success standards contain more specific reference to monitoring the avian community. These sites receive three bird surveys conducted during the breeding season (May and June). The point count method (Ralph et al. 1993) is used to document species richness and relative abundance.

Species diversity indices (H) may be calculated from bird survey data using the Shannon-Wiener function (Krebs 1999). Results are expressed as a mean annual species diversity index.

$$H' = -\sum_{i=1}^{s} (p_i)(\log p_i)$$

H' = index of species diversity
s = number of species
p_i = proportion of sample belonging to ith species

The following *t*-test is used to test the null hypothesis that diversity indices from different years are equal (Zar 1999).

$$t = \frac{H'_1 - H'_2}{S_{H'_1 - H'_2}}$$

H' = index of species diversity
$S_{H'_1 - H'_2}$ = standard error of the difference between species diversity indices H'_1 and H'_2

Amphibian Monitoring

Sites with goals, objectives, or standards referencing amphibians may be monitored using methods adapted from Olson et al. (1997). Methods may include funnel trapping on sites with a water depth of one decimeter or greater. Call surveys and area searches may be used to assess terrestrial components of sites without standing water. Incidental amphibian observations are recorded during other monitoring activities. Potential for amphibian habitat may be qualitatively assessed.

Hydrology Monitoring

Primary and secondary field indicators of wetland hydrology (Ecology 1997) are recorded to address hydrology standards and to aid in future delineation efforts. Wetland mitigation sites are delineated in the spring following the last year of vegetation monitoring so the actual wetland area can be compared to the planned wetland area.

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Grays Harbor/Thurston County Mitigation Sites

SR 12 Black River SSDP – 98 0882

Photo 3.1 A developing wetland tree and shrub community at SR 12 Black River.

SR 12 Black River SSDP – 98 - 0882

This report summarizes management and monitoring activities completed by the Washington State Department of Transportation (WSDOT) at the SR 12 Vicinity Black River Bridge & SR 12 Vicinity Moon Road mitigation site (SR 12 Black River) from Fall 2003 through Fall 2004 (Photo 3.1). WSDOT Wetland Monitoring and Assessment Program activities were intended to address success standards for 2004. These activities include surveys of wetland hydrology and invasive vegetation. Table 3.1 provides general site information and Table 3.2 summarizes this year's monitoring results

Table 3.1 General Information for the SR 12 Black River Mitigation Site

Thurston County Shoreline Substantial Development Permit	SSDP-98-0882		
Township/Range/Section (impact)	T.16 N/R.4W/S.35, 36 & T.6N/R.4W/S.33		
Mitigation Location	North of SR 12 on Anderson Road, Gray's Harbor County		
Construction Date	1999		
Initial Monitoring Period	2000 to 2004		
Year of Monitoring	5 of 5		
Area of Project Impact	1.92 acres		
Type of Mitigation	Wetland Creation	Preservation	Enhancement
Area of Mitigation	2.90 acres	4.50 acres	0.11 acres

Table 3.2 Monitoring and Management Summary for the SR 12 Black River Mitigation Site

Performance Criteria	2004 Results[9]	Management Activities
Success Standards		
1. Hydrology present at least 12.5% of the growing season (consecutive)	Present	
2. Less than 20% reed canarygrass or other invasive species	23% ($CI_{80\%}$= 19- 27%)	Weed control

Success Standards and Sampling Objectives

Fifth-year success standards for the SR 12 Black River mitigation site were excerpted from the *SR 12 Vicinity Black River Bridge & SR 12 Vicinity Moon Road SR Combined Conceptual Wetland Mitigation Plan* (Russell 1998). A sampling objective follows the success standard where appropriate. Appendix 3.1 provides a complete text of the success standards for this project and Appendix 3.2 shows the planting plan and photo locations (Russell 1998).

Success Standard 1

Hydrology (within 12 inches of the soil surface) within the wetland creation area must be present for at least 12.5% of the growing season (2004).

[9] Estimated values are presented with their corresponding statistical confidence interval. For example, 23% ($CI_{80\%}$ = 19-27%) means we are 80% confident that the true value is between 19% and 27%.

Success Standard 2
Cover of reed canarygrass, or other invasive species may not exceed 20% of the total wetland area at any time during any years one through five.

Sampling Objective 1
To be 80% confident the true aerial cover of invasive species in the wetland area is within 20% of the estimated value.

Methods

To address Success Standard 1, primary and secondary field indicators of wetland hydrology (Ecology 1997) were recorded. Observations were made during visits on March 3, April 5, and May 13, 2004.

To evaluate the aerial cover by invasive species fifty-five temporary sampling transects were placed perpendicular to a baseline using a systematic random sampling method (Figure 3.1). Eighty-eight 20-meter point-line sample units (40 points each) were randomly positioned along sampling transects.

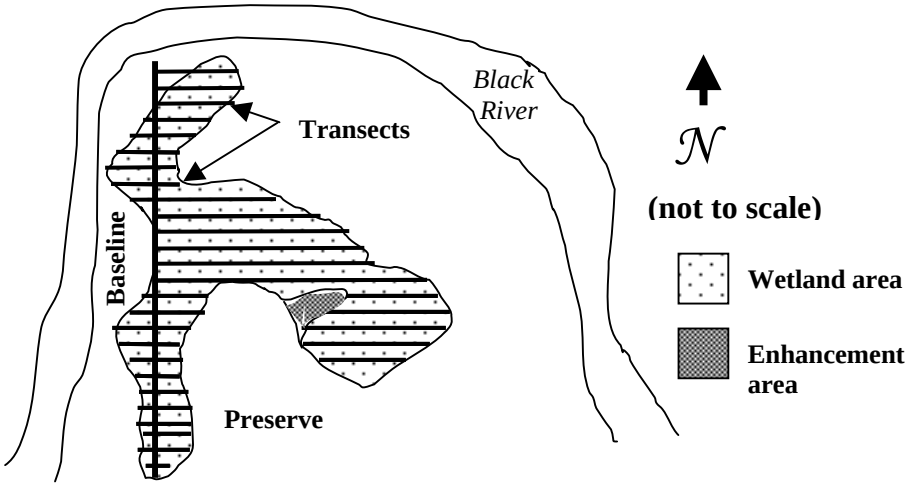


Figure 3.1 **SR 12 Black River Mitigation Site Sampling Design (2004)**

Sample size analysis confirmed that sufficient sampling had been completed based on the sampling objectives and the desired level of statistical confidence. The following sample size equation was used to perform the analysis on data collected.

$$n = \frac{(z)^2 (s)^2}{(B)^2}$$

z = standard normal deviate
s = sample standard deviation
B = precision level[10]
n = unadjusted sample size

For additional details on the methods described above, see the Methods section of this report, or go to this address:
http://www.wsdot.wa.gov/environment/biology/docs/MethodsWhitePaper052004.pdf

Results and Discussion

Success Standard 1 – Wetland Hydrology Present For 12.5% of The Growing Season

Surveys conducted on March 3 and April 5, 2004 yielded evidence of wetland hydrology. During both visits, lower areas of the site were inundated to 2 decimeters, with other wetland areas saturated to within 12 inches of the surface. (Photo 3.2). The site was dry by May 13, 2004. These data are consistent with hydrologic observations made in 2001, 2002, and 2003. The third year wetland delineation conducted on January 22, 2003 concluded that the intended wetland acreage had been created. These observations suggest that the success standard for site hydrology has been met.

Photo 3.2 **Surface Water at the SR 12 Black River Mitigation Site (March 2004)**

Success Standard 2 – Invasive Species May Not Exceed 20% of Total Cover

Weed control during the past five years has been effective at meeting this standard (Table 3.3). In 2004, aerial cover provided by invasive species in the planted areas was estimated to be 23% ($CI_{80\%}$ = 19-27% cover) with *Phalaris arundinacea* (reed canarygrass) accounting for the majority of the cover. Subsequent weed control was implemented two weeks after monitoring occurred with the intention of bringing invasive cover back below the threshold. Table 3.4 identifies the species of concern for this site.

[10] The precision level equals half the maximum acceptable confidence interval width multiplied by the sample mean.

Table 3.3 Management Activities at SR 12 Black River from 2001-present

Date	Management Activity
Summer 2001	*P. arundinacea*, *Senicio jacobaea* (tansy ragwort), and *Rubus* (blackberry) species were removed by mechanical methods and spot spraying of herbicides. Stressed plantings watered as needed.
Summer 2002	*P. arundinacea and Rubus* species removed by mechanical methods and spot spraying of herbicides. Stressed plantings watered as needed.
Fall/Winter 2002/2003	*P. arundinacea* and *Rubus* species removed by mechanical methods and spot spraying of herbicides. Stressed plantings watered as needed.
Summer 2004	*P. arundinacea* spot sprayed with herbicide.

Table 3.4 Invasive Species at the SR 12 Black River Mitigation Site as of 2004

Scientific Name	Common Name
Cirsium arvense	Canada thistle
Cirsium vulgare	bull thistle
Daucus carota	Queen Anne's lace
Hypochaeris radicata	hairy cat's ear
Leucanthemum vulgare	oxeye daisy
Phalaris arundinacea	reed canarygrass
Rubus armeniacus	Himalayan blackberry
Sencio jacobaea	tansy ragwort

Additional Information

Woody plant survival assessments were conducted in each of the first three years of monitoring. Results from each survey showed a planted tree and shrub community with very low mortality. In addition, site observations early in the monitoring period revealed a substantive level of naturally colonizing native trees. Volunteer *Fraxinus latifolia* (Oregon ash), *Alnus rubra* (red alder), *Populus balsamifera,* (black cottonwood) and *Salix* species (willows) enhance the community of surviving planted trees and shrubs. Although not required by fifth-year standards, aerial cover of woody species was evaluated to provide an added measure of how the tree and shrub community is developing. Aerial cover provided by woody species is estimated to be 24% ($CI_{90\%}$ = 22–28%). Although aerial cover is currently low, and unevenly distributed, the site should develop into a complex forested wetland with time. Table 3.5 identifies woody species that were observed at the site.

Table 3.5 Observed Woody Species at SR 12 Black River Mitigation Site

Scientific Name	Common Name
Alnus rubra	red alder
Cornus sericea	redosier dogwood
Fraxinus latifolia	Oregon ash
Physocarpus capitatus	Pacific ninebark
Populus balsamifera	black cottonwood
Rubus spectabilis	salmonberry
Salix lucida ssp *lasiandra*	Pacific willow
Salix sitchensis	Sitka willow
Spiraea douglasii	hardhack

Wildlife

Wildlife habitat replacement was listed as a primary goal of this wetland mitigation effort (Russell 1998). Incidental wildlife observations over the five-year monitoring period yielded evidence of elk (*Cervus canadensis*), black-tailed deer (*Odocoileus hemionus*), and coyotes (*Canis latrans*). Garter snakes (*Thamnophis cyrtopsis*) were also observed on most site visits.

Photo 3.3 Bird's nest at the SR 12 Black River mitigation site (July 2004).

Incidental observations also documented 29 avian species from 17 families on site. Of these, six species are classified as wetland-dependent and four as wetland-associated.[11] This bird activity may be due to the close proximity of Black River to this site. Photo 3.3 shows evidence that avian species used the site for nesting. Table 3.6 shows species documented on site and their wetland status.

Table 3.6 Wetland-Dependent and Associated Avian Species Observed at SR 12 Black River Mitigation Site from 2000-2004.

Common Name	Scientific Name	Wetland Status
Belted Kingfisher	*Ceryle alcyon*	Wetland-dependent
Common Yellowthroat	*Geothlypis trichas*	Wetland-dependent
Great Blue Heron	*Ardea herodias*	Wetland-dependent
Northern Harrier	*Circus cyaneus*	Wetland-dependent
Red-winged Blackbird	*Agelaius phoeniceus*	Wetland-dependent
Wilson's Snipe	*Gallinago delicata*	Wetland-dependent
Barn Swallow	*Hirundo rustica*	Wetland-associated
Black-capped Chickadee	*Poecile atricapillus*	Wetland-associated
Tree Swallow	*Tachycineta bicolor*	Wetland-associated
Violet-green Swallow	*Tachycineta thalassina*	Wetland-associated

[11] Birds are assigned upland or wetland-dependent species status based on the classification scheme presented in Brown and Smith (1998). Regional variation occurs. Additional references used to further classify bird species include Thomas (1979), Ehrlich et al. (1998), and Smith et al. (1997).

Appendix 3.1 – SR 12 Black River Standards of Success

The following excerpt is from the *SR 12 Vicinity Black River Bridge & SR 12 Vicinity Moon Road SR 12 Milepost 37.33 to 37.61 & Milepost 39.63 to 40.01 OL 3192 & OL 3174 Combined Conceptual Wetland Mitigation Plan* (Russell 1998). The standards addressed this year are identified in **bold** font.

Standard of Success

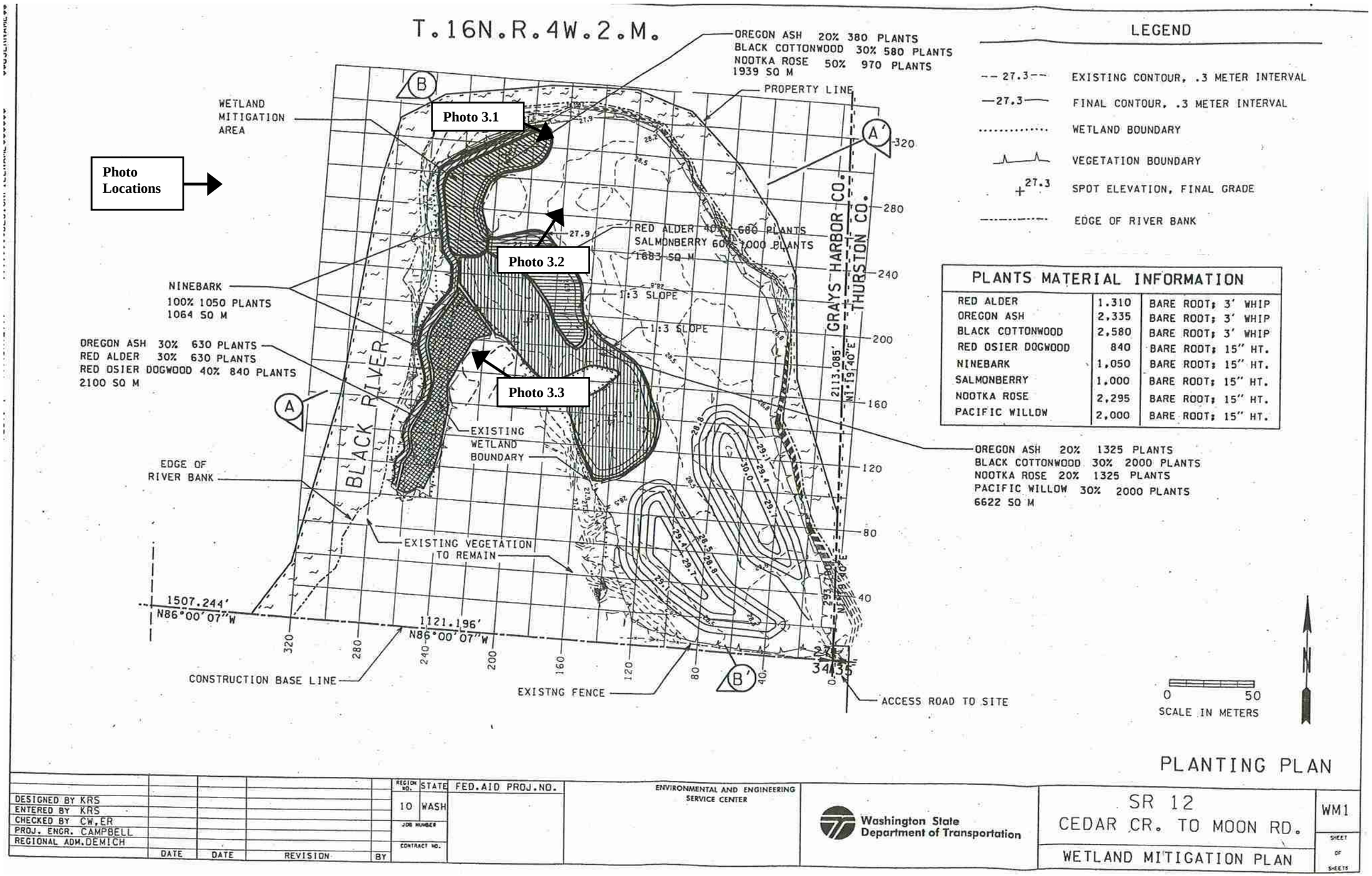
- **100% survival (or replacement) of trees and shrubs at the end of year one**. Non-invasive volunteer species are acceptable in all zones and may be used in estimating percent cover of emergent species and credited toward survival of planted trees and shrubs.

- Vegetative success must equal or exceed 80 percent survival of planted trees and shrubs by the end of year three, or additional planting (and monitoring) to achieve success.

- **Hydrology (within 12 inches of the soil surface) within the wetland creation area must be present for at least 12.5% of the growing season (consecutive).**

- **Cover of reed canarygrass, or other invasive species may not exceed 20 percent of the total wetland area at any time during any years one through five.**

Appendix 3.2 – SR 12 Black River Planting Plan
(Russell 1998)



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10. Washington State Department of Transportation (WSDOT) *WSDOT Wetland Mitigation Site Monitoring Methods* (25 May 2004). http://www.wsdot.wa.gov/environment/biology/docs/MethodsWhitePaper052004.pdf

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Pierce County Mitigation Sites

SR 7 Nisqually Slough USACE NWP 2000-4-00954

Photo 4.1 **Overview of the SR 7 Nisqually Slough mitigation site from the southwest corner to the northeast.**

SR 7 Nisqually Slough USACE NWP 2000-4-00954

This report summarizes management and monitoring activities completed by the Washington State Department of Transportation (WSDOT) at the SR 7 Nisqually Slough mitigation site from Fall 2003 through Fall 2004 (Photo 4.1). WSDOT Wetland Monitoring and Assessment Program activities in 2004 were intended to evaluate the site with respect to third year (2004) success standards. Activities include vegetation surveys and assessments of wetland hydrology. Table 4.1 provides general site information and Table 4.2 summarizes this year's monitoring results.

Table 4.1 General Information for the SR 7 Nisqually Slough Mitigation Site

USACE NWP 23 Number	2000-4-00954
Pierce County Shoreline Substantial Development Permit	SD23-99
HPA Permit Number	00-E4638-01
Township/Range/Section (impact)	T.18N/R.3E/S.24, 25, 36
Mitigation Location	South of Wilcox Farms near the Nisqually River, Pierce County
Construction dates	2001 to 2002
Monitoring Period	2002 to 2006
Year of Monitoring	3 of 5
Area of Project Impact	0.75 acres
Type of Mitigation	Wetland Creation
Area of Mitigation	0.82 acres

Table 4.2 Monitoring and Management Summary for the SR 7 Nisqually Slough Mitigation Site

	Performance Criteria	2004 Results[12]	Management Activities
1.	Less than 20% reed canarygrass or invasives in wetland or buffer	Wetland: 3% ($CI_{80\%}$ = 0-5% cover) Buffer: 10% ($CI_{80\%}$ = 8-13% cover)	Weed control
2.	Wetland hydrology 12.5% growing season	Present	
3.	At least 70% cover by grasses and forbs	95% ($CL_{99\%}$ = 92% - 98% cover)	

Success Standards and Sampling Objectives

The success standards for the SR 7 Nisqually Slough mitigation site were excerpted from the *SR 7 MP 40 to MP 42.5 Wetland Mitigation Plan* (Russell 1999). Companion sampling objectives follow the success standards where appropriate. Appendix 4.1 provides a complete text of the revised and original success standards for this project and Appendix 4.2 shows the planting plan (Russell 1999).

[12] Estimated values are presented with their corresponding statistical confidence interval. For example, 3% ($CI_{80\%}$ = 0-5% cover) means we are 80% confident that the true aerial cover value is between 0% and 5%.

Success Standard 1
Cover of reed canarygrass, or other invasive species may not exceed 20% of the total wetland or buffer area at any time during years one through five (2002-2006).

Sampling Objective 1A
To be 80% confident the true aerial cover of invasive species in the wetland is within 20% of the estimated value.

Sampling Objective 1B
To be 80% confident the true aerial cover of invasive species in the buffer is within 20% of the estimated value.

Success Standard 2
70% cover of grasses and forbs within the wetland creation and upland buffer areas by the end of year three (2004).

Sampling Objective 2A
To be 80% confident the true aerial cover of grasses and forbs in the wetland is within 20% of the estimated value.

Sampling Objective 2B
To be 80% confident the true aerial cover of grasses and forbs in the upland buffer is within 20% of the estimated value.

Success Standard 3
Hydrology (within 12 inches of the soil surface) within the wetland creation area must be present for at least 12.5% of the growing season (consecutively) (2004).

Methods

To evaluate aerial cover of invasive species, 31 temporary transects were placed perpendicular to a center baseline using a systematic random sampling method (Figure 4.1). Twenty-two 12-meter point-line sample units (24 points each) were randomly positioned along sampling transects in the wetland creation area. Forty-one 12-meter point-line sample units (24 points each) were randomly positioned in the upland (Success Standard 1). The same sample units were used to evaluate aerial cover of grasses and forbs (Success Standard 2).

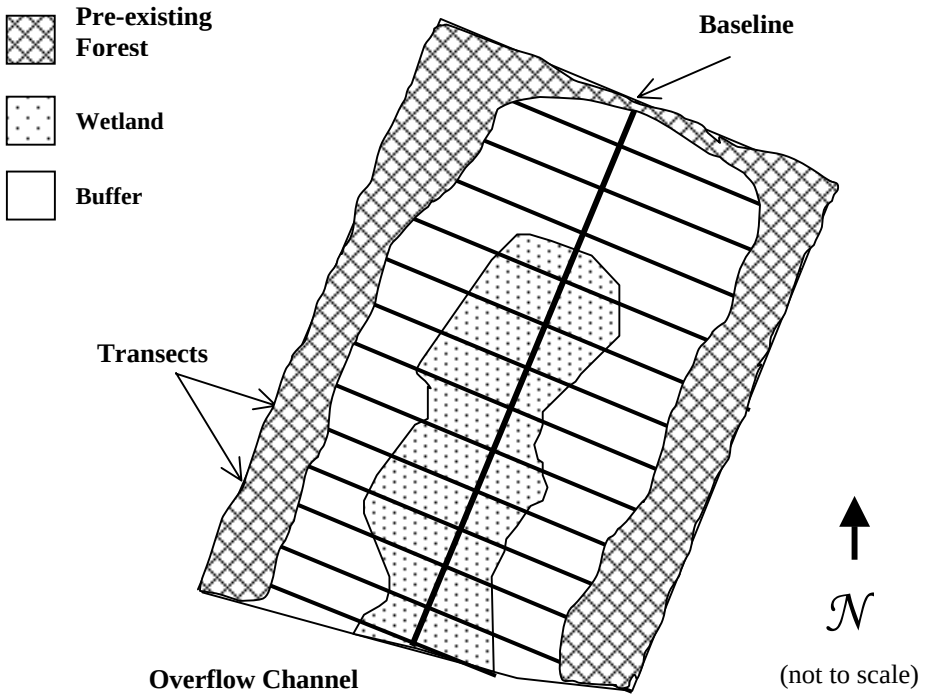


Figure 4.1 SR 7 Nisqually Slough Mitigation Site Sampling Design (2004)

Sample size analysis confirmed that sufficient sampling had been completed based on the sampling objectives and the desired level of statistical confidence. The following sample size equation was used to perform the analysis on data collected.

$$n = \frac{(z)^2 (s)^2}{(B)^2}$$

z = standard normal deviate
s = sample standard deviation
B = precision level[13]
n = unadjusted sample size

WSDOT staff recorded primary and secondary field indicators of wetland hydrology (Ecology 1997) in March and April 2004 (Success Standard 3).

For additional details on the methods described above, see the Methods section of this report or the WSDOT Wetland Mitigation Site Monitoring Methods at: http://www.wsdot.wa.gov/environment/biology/docs/MethodsWhitePaper052004.pdf

[13] The precision level equals half the maximum acceptable confidence interval width multiplied by the sample mean.

Results and Discussion

Success Standard 1a – Maintain Less Than 20% Invasive Species in the Wetland
In 2003, weed control was conducted four times (Table 4.3). The aerial cover of invasive species in the wetland is estimated to be 3% ($CI_{80\%}$ = 0-5% cover), well below the maximum allowed by Success Standard 1. *Phalaris arundinacea* (reed canarygrass) and *Rubus armeniacus* (Himalayan blackberry) were the only invasive species observed. Most of the *P. arundinacea* was concentrated in the southern quarter of the site in the area of dense willow plantings near the Nisqually River overflow channel. The willows in this area appear to be established and most are taller than the *P. arundinacea*. Regularly scheduled weed control was also conducted after monitoring to maintain the low cover.

Table 4.3 Management Activity Summary for the SR 7 Nisqually Slough Mitigation Site

Date	Adaptive Management
May 03	Tested herbicide for effectiveness on *Cytisus scoparius* (Scot's broom), *Rubus* spp., and *Cirsium* spp. (thistles).
June 03	Berm was watered and seeded. *C. scoparius* was removed.
July 03	Sprayed *C. scoparius*, *Rubus* spp., and *P. arundinacea*. Also installed fence, hand weeded around mulch rings, watered plants on berm and riparian areas.
Oct. 03	Re-planted 45 trees and 65 shrubs with fertilizer, gel polymer, and bark rings.
July 04	Sprayed herbicide on *Phalaris arundinacea* (reed canarygrass), *C. scoparius, Rubus* spp.

Success Standard 1b – Maintain Less Than 20% Invasive Species in the Buffer
The aerial cover of invasive species in the buffer is estimated to be 10% ($CI_{80\%}$ = 8-13% cover). *P. arundinacea*, *Cirsium* species (thistles), *C. scoparius*, *R. armeniacus*, and *Rubus laciniatus* (cutleaf blackberry) were the invasive species observed in the buffer. *Senecio jacobaea* (tansy ragwort) was not included in sample units, but is present at trace levels.

Combined aerial cover on the wetland and buffer is estimated to be 8% ($CI_{80\%}$ = 6-10% cover). These estimates are well below the maximum allowed by Success Standard 1.

Success Standard 2 –70% Cover of Grasses and Forbs in the Wetland and Upland Buffer
The aerial cover of grasses and forbs in all zones is estimated to be 95% ($CI_{99\%}$ = 92% - 98%). The aerial cover estimates of grasses and forbs in the wetland and upland areas are 97% ($CL_{99\%}$ = 93% - 100%) and 94% ($CL_{99\%}$ = 91% - 98%), respectively. Each of these estimates is well above the minimum required by Success Standard 2.

Native herbaceous wetland plants observed in the planned wetland include: *Juncus effusus* (soft rush), *Juncus ensifolius* (daggerleaf rush), *Scirpus microcarpus* (small-fruited bulrush), *Carex stipata* (sawbeak sedge), and *Glyceria* species (mannagrasses) (Photo 4.2).

Photo 4.2 **SR 7 Nisqually Slough cover by grasses and forbs (July 2004)**

Success Standard 3 – Wetland Hydrology

Wetland hydrology was evaluated in March and April 2004 (Photo 4.3). During these visits, small areas of surface water (less than 1 decimeter in depth) were present, and soils were saturated to the surface throughout the wetland areas. These observations suggest that the hydrology criteria under Goal 2 and Successes Standard 3 were met.

Photo 4.3 **SR 7 Nisqually Slough hydrology (March 2004)**

Additional Information

The mitigation plan goals are to create a recognizable plant community that will develop into a forested wetland, and upland buffer community. Presently there are many volunteer *Populus balsamifera* (black cottonwood) in the wetland that in combination with the planted woody species should result in a forested wetland with time.

The monitoring plan (Russell 1999) requires three formal bird surveys and observation of wildlife signs. During point-count bird surveys in 2002 through 2004 a total of 21 avian species were observed on site. An additional 23 species were documented within 30 meters of the site, including two wetland-dependent species: Common Yellowthroat

(Geothlypis trichas) and Mallard *(Anas platyrhynchos*).[14] Twenty-four families are represented among the 44 total species observed.

In addition, incidental wildlife observations include garter snakes (*Thamnophis cyrtopsis*), rabbits, small mammal burrows, browse, and coyote (*Canis latrans*), rabbit, deer, and elk scat. These observations indicate that the general goal of providing wildlife habitat is being satisfied.

[14] Birds are assigned upland or wetland-dependent species status based on the classification scheme presented in Brown and Smith (1998). Regional variation occurs. Additional references used to further classify bird species include Thomas (1979), Ehrlich et al. (1998), and Smith et al. (1997).

Appendix 4.1 – SR 7 Nisqually Slough Success Standards

The standards addressed this year are identified in **bold** font. Other standards will be addressed in the indicated monitoring year.[15]

- 100% Survival (or replacement) of trees and shrubs at the end of year one. Non-invasive volunteer species are acceptable to include in this total.

- **70% cover of grasses and forbs within the wetland creation and upland buffer areas by the end of year three**.

- Tree and shrub canopy aerial canopy cover within the wetland creation area will meet or exceed 60 % by the end of year five. Non-invasive volunteer species are acceptable to include in this assessment.

- Tree and shrub canopy cover within the planted upland buffer area will meet or exceed 30% by the end of year five. Non-invasive volunteer species are acceptable to include in this assessment.

- **Hydrology (within 12 inches of the soil surface) within the wetland creation area must be present for at least 12.5% of the growing season (consecutively). Although reasonable assumptions based on site observations (vegetation, soil, hydrology indicators) can be made each year during the early part of the growing season so that direct observations of hydrology can be made.**

- **Cover of reed canarygrass, or other invasive species may not exceed 20 percent of the total wetland or buffer area at any time during years one through five.**

Excerpted from the *SR 7 MP 40 to MP42.4 Wetland Mitigation Plan* (Russell 1999). Old success standards are lined-out and replaced by standards listed above.

GENERAL GOALS

The general goal of the wetland mitigation plan is to create 3,300 square meters (35,522.10 square feet) of forested wetland, as well as enhance adjacent upland buffer area, which will provide wildlife habitat, groundwater recharge, and water quality functions. The following summarizes the goals that must be met by the third growing season after monitoring:

[15] A letter (dated 1-8-03) from Carl Ward to Dave Risvold of the Pierce County Department of Planning and Land Services revises the Goals and Success Standards to those presented above.

- Create a recognizable plant community that will develop into a forested wetland, and upland buffer community.

- Create a seasonally saturated wetland hydrologic regime that meets the criteria of the 1997 Washington State Manual (Ecology 1997), i.e., at least 12.5% of the growing season.

- Create a hydrologic connection between Wetland A (the slough of the Nisqually River) and the created wetland area.

The following summarizes the performance standards that the wetland creation and enhancement areas must meet:

- 100 percent survival (or replacement) of trees and shrub species at the end of year one. Non-invasive volunteer species are acceptable in all zones and may be used in estimating percent cover and credited toward survival of planted trees and shrubs.

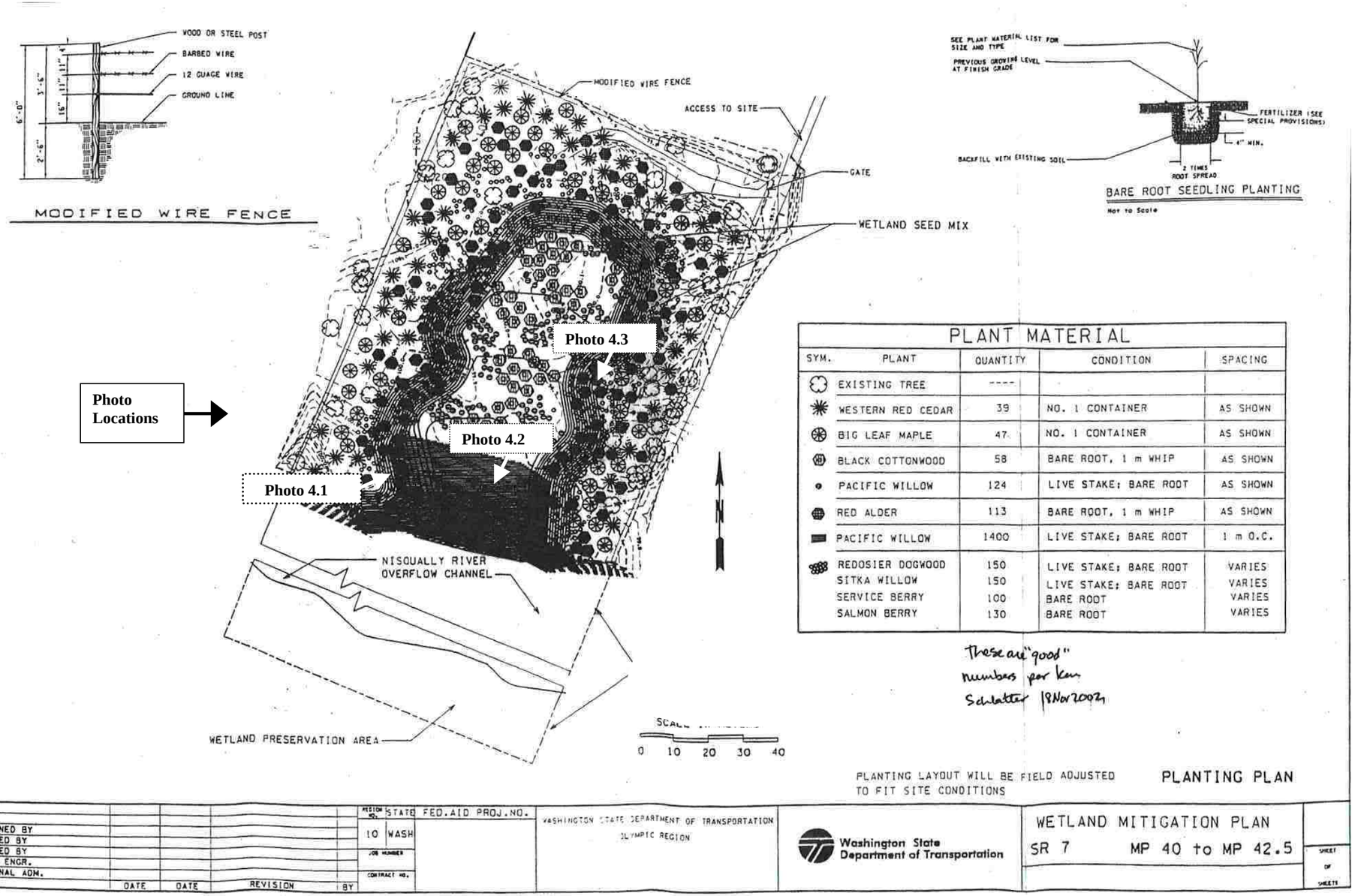
The following summarized the performance standards that the upland buffer enhancement areas must meet:

- 100% survival (or replacement) of trees and shrubs at the end of year one. Non-invasive volunteer species are acceptable in all zones and may be used in estimating toward survival of planted trees and shrubs**.**

CONTIGENCY PLAN

In the event that the goals and objectives are not met by the third year, contingency measures must be taken. These include but are not limited to replanting dead plants, hydrologic manipulation, irrigation, mulching of plants, weed control, trash removal, erosion repair, and any other practices necessary to meet the goals of the mitigation plan. Recommendations to correct deficiencies will be made after each site visit by the wetland biologist. WSDOT will correct deficiencies in a timely and responsible manner.

Appendix 4.2 – SR 7 Nisqually Slough Planting Plan
(WSDOT 1999).



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13. Washington State Department of Transportation (WSDOT) *WSDOT Wetland Mitigation Site Monitoring Methods* (25 May 2004). http://www.wsdot.wa.gov/environment/biology/docs/MethodsWhitePaper052004.pdf

14. Ward, C. to D. Risvold of Pierce County Department of Planning and Land Services. Letter dated 8 January 2003.

Photo 5.1 An overview of the SR 161 Kapowsin Mitigation Site looking southwest

SR 161 Kapowsin USACE NWP 93-4-01100

The following report summarizes monitoring activities completed by the Washington State Department of Transportation (WSDOT) at the MP 13 to MP 14 Safety Improvements (SR 161 Kapowsin) mitigation site in August 2004. Monitoring data were obtained to compare to third-year success standards. Activities include surveys of wetland hydrology and vegetation. Table 5.1 provides general site information and Table 5.2 summarizes this year's monitoring results.

Table 5.1 General Information for the SR 161 Kapowsin Mitigation Site

USACE NWP 23 Permit Number	98-3-00146
Pierce County Permit Number	9806230585
Township/Range/Section (impact)	T.26N/R.12E/S.25,26,27,28
Mitigation Location	West side of SR 161 just South of the SR 161 / South Fork Muck Creek Crossing, Pierce County
Construction date	2002
Monitoring Period	2002 to 2006
Year of Monitoring	3 of 5
Area of Project Impact	0.16 acres
Type of Mitigation	Wetland Creation/Enhancement
Area of Mitigation	0.32 acres

Table 5.2 Monitoring and Management Summary for the SR 18 Kapowsin Mitigation Site

Performance Criteria	2004 Results[16]	Management Activities
Success Standard		
1. Hydrology at least 12.5% of growing season	Present	
2. Less than 20% invasive species	7% ($CI_{80\%}$ = 5% - 9% cover)	Ongoing weed control

Success Standards and Sampling Objectives

The success standards for the SR 161 Kapowsin mitigation site were excerpted from the *MP 13 to MP14 Safety Improvements Wetland Mitigation Plan* (Russell 1998). A companion sampling objective follows the success standard where appropriate. Appendix 5.1 provides the complete text of the goals and success standards for this project and Appendix 5.2 shows the planting plan (Russell 1998).

Success Standard 1
Hydrology (within 12 inches of the soil surface) within the wetland creation area must be present for at least 12.5% of the growing season (consecutive) (2002-2006).

[16] Estimated values are presented with their corresponding statistical confidence interval. For example, 7% ($CI_{80\%}$ = 5-9% aerial cover) means we are 80% confident that the true aerial cover value is between 5% and 9%.

Success Standard 2
Cover of reed canary grass, or other invasive species may not exceed 20% of the total wetland area at any time during years one through five (2002-2006).

Sampling Objective
To be 80% confident the true cover of invasive species is within 20% of the estimated value.

Methods

To address Success Standard 1, primary and secondary field indicators of wetland hydrology (Ecology 1997) were recorded. Observations were made during visits on March 3 and April 1, 2004.

To evaluate aerial cover of *Phalaris arundinacea* (reed canarygrass), 23 temporary transects were placed perpendicular to a baseline using a systematic random sampling method (Figure 5.1). Thirty-six 20-meter point-line sample units (40 points each) were randomly positioned along sampling transects (Success Standard 2).

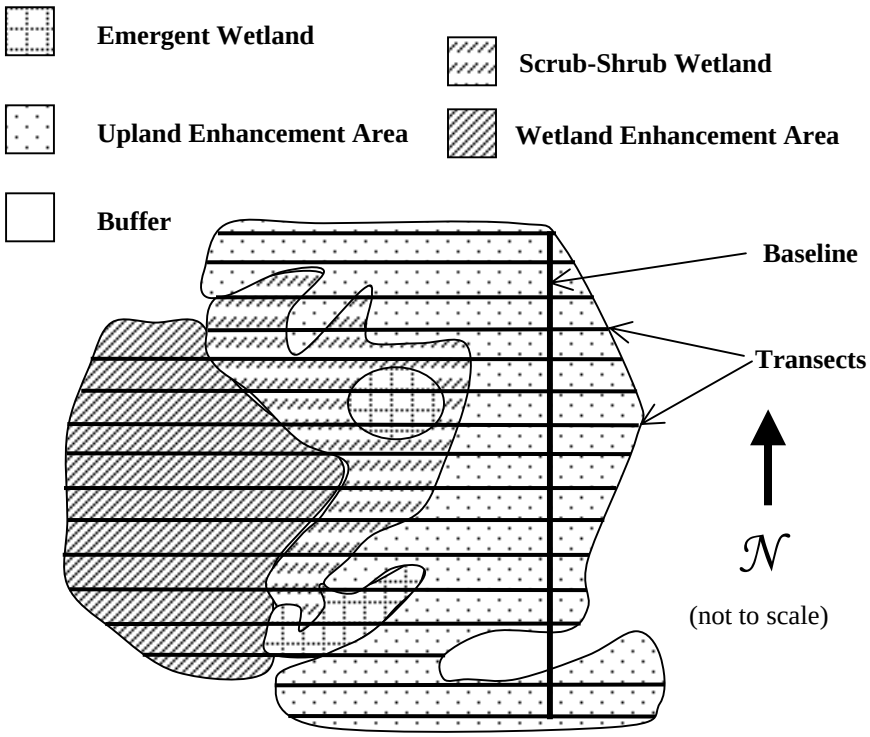


Figure 5.1 SR 161 Kapowsin Mitigation Site Sampling Design (2004)

Sample size analysis was conducted using the following equation.

$$n = \frac{(z)^2 (s)^2}{(B)^2}$$

z = standard normal deviate
s = sample standard deviation
B = precision level[17]
n = unadjusted sample size

For additional details on the methods described above, see the Methods section of this report, or go this address:
http://www.wsdot.wa.gov/environment/biology/docs/MethodsWhitePaper052004.pdf

Results and Discussion

Success Standard 1 – Hydrology for at least 12.5% of the Growing Season
Hydrology observations have indicated that the intended hydrologic conditions have been achieved. Two visits were made early in the 2004 growing season. In March, 5-10% of the site was inundated to one decimeter. In other areas, soil saturation was observed within four inches of the surface in soil pits. New growth of several plant species and swollen buds on trees were observed confirming the growing season had started. During a second hydrology visit in April, soils were saturated within 4 inches of the surface throughout the wetland with some small areas of inundation.

Success Standard 2 – Less Than 20% Cover of Invasives
Aerial cover provided by *P. arundinacea* and other invasive species on site is estimated to be 7% ($CI_{80\%}$ = 5-9% cover). This is below the 20% threshold for invasive species cover, thus achieving Success Standard 2. *Cirsium arvense* (Canada thistle) contributes the majority of the cover. Several other undesirable species were identified on site and are listed in Table 5.3. These species are the target of weed control efforts.

Table 5.3 Invasive Species at the SR 161 Kapowsin Mitigation Site (2004)

Scientific Name	Common Name
Cirsium arvense	Canada thistle
Cirsium vulgare	bull thistle
Hypericum perforatum	common St. Johnswort
Leucanthemum vulgare	oxeye daisy
Phalaris arundinacea	reed canarygrass
Rubus armeniacus	Himalayan blackberry
Rubus laciniatus	cutleaf blackberry

[17] The precision level equals half the maximum acceptable confidence interval width multiplied by the sample mean.

Additional Information

The mitigation plan (Russell 1998) requires that by year three, a forested wetland and upland buffer community will be established (Appendix 5.1). High mortality and slow development of surviving plants have hindered achievement of this goal. Browse from ungulates, and dry soil conditions in late summer may be factors affecting plant establishment. Photo 5.2 shows the site looking southeast to northwest.

Photo 5.2 The SR 161 Kapowsin Mitigation Site (2004)

Site goals also state a third year criterion that a hydrologic connection between Muck Creek and the created and enhanced wetland areas be maintained (but not expanded) (Russell 1998). Site observations indicate that the intended hydrologic conditions are present.

The provision of wildlife habitat is an overall goal for this mitigation site. As specified in the plan (Russell 1998), three formal bird surveys have been conducted on site each season in May and June. A total of 18 avian species have been documented on site during point-count surveys. An additional 15 species have been observed within 30 meters of the site. Of these species 8 are considered wetland-dependent or wetland-associated (Table 5.4).[18] Seventeen families are represented among the 33 total species observed. Ungulate scat and browse have also been repeatedly observed on site throughout the monitoring period. These observations show that birds and large mammals are utilizing the site.

Table 5.4 Wetland Dependent and Wetland Associated Birds Observed at the SR 161 Kapowsin Mitigation Site

Species Name	Status
Black-capped Chickadee	wetland-associated
Common Yellowthroat	wetland-dependent
Marsh Wren	wetland-dependent
Tree Swallow	wetland-associated
Violet-green Swallow	wetland-associated
Willow Flycatcher	wetland-associated
Wilson's Warbler	wetland-associated
Yellow Warbler	wetland-associated

[18] Birds are assigned upland or wetland-dependent species status based on the classification scheme presented in Brown and Smith (1998). Regional variation occurs. Additional references used to further classify bird species include Thomas (1979), Ehrlich et al. (1998), and Smith et al. (1997).

Management Activities

Management activities for the past two years are summarized in Table 5.5.

Table 5.5 Management Activity Summary for the SR 161 Kapowsin Mitigation Site (2003-2004)

Date	Management Activity
7/21/03	Watered plantings, browse guards placed on plantings; slow release fertilizer placed around base of plantings; weed control.
8/5/04	Watered plantings; placed more browse guards on plantings; weed control.
10/15/04	Replanted 50 plantings representing 7 native species; weed control.

Appendix 5.1 – SR 161 Kapowsin Success Standards

The following excerpt is from the *MP 13 to MP14 Safety Improvements Wetland Mitigation Plan* (Russell 1998). The criteria addressed this year are identified in **bold** font. Other tasks and standards will be addressed in the indicated monitoring year.

GOALS AND PERFORMANCE STANDARDS

The general goal of the wetland mitigation plan is to create or enhance approximately .12 hectares (.32 acres) of forested wetland, as well as enhance .12 hectares (.32 acres) of upland buffer area, which will provide wildlife habitat, groundwater recharge, and water quality functions. The following summarized the goals that must be met by the third growing season after monitoring:

- **Create a recognizable plant community that will develop into a forested wetland, and upland buffer community.**

- **Create a seasonally saturated wetland hydrologic regime that meets the criteria of the 1997 Washington State Manual (DOE, 1997), i.e. at least 12.5% of the growing season.**

- **Maintain, but not expand, a hydrologic connection between Muck Creek and the created and enhanced wetland areas.**

The following summarizes the performance standards that the wetland creation and enhancement areas must meet:

- 100% survival (or replacement) of trees, shrubs, and emergent species at the end of year one. Non-invasive volunteer species are acceptable in all zones and may be used in estimating percent cover of emergent species and credited toward survival of planted trees and shrubs.

- Vegetative success must equal or exceed 80 percent survival of planted trees and shrubs, and 80 percent cover of emergent species by the end of year five, or additional planting (and monitoring) to achieve such.

- **Hydrology (within 12 inches of the soil surface) within the wetland creation area must be present for at least 12.5% of the growing season (consecutive).**

- **Cover or reed canarygrass, or other invasive species may not exceed 20 percent of the total wetland area at any time during years one through five.**

The following summarizes the performance standards that the upland buffer enhancement areas must meet:

- 100% survival (or replacement) of trees and shrubs at the end of year one. Non-invasive volunteer species are acceptable in all zones and may be used in estimating toward survival of planted tress and shrubs.

- Vegetative cover (grass herbaceous material) in upland buffer areas is a minimum of 90 percent after year five.

Using the Canopy Coverage Method during years 1-2, and the Line Intercept Method during years 4-5, the following standards of success for vegetative growth in all areas (as applicable) shall be met as shown in Table 3:

Table 3. Vegetative standards of success by year and layer for wetland creation and enhancement, and upland enhancement areas (as applicable).

	Tree	Shrub	Emergent
Year #1	20%	30%	30%
Year #2	20%	40%	50%
Year #4	40%	50%	70%
Year #5	40%	60%	80%

MAINTENANCE AND MONITORING PLAN

The following list features of the wetland creation project which will or may require on-going maintenance. Although it strives to include all potential maintenance needs, unforeseen problems are likely to arise. Therefore, it is essential that WSDOT personnel the site at least 2 times a year during the first two growing seasons following construction to assure that maintenance or corrections are promptly made. In addition to the 4 visits during years 1 and 2, monitoring will also occur in years 4 and 5.

- Loss of tree or shrub species (wetland and buffer species) for various reasons-replace or replant as needed.

- Presence of reed canarygrass, or other invasive species – hand pull monthly May-August, wick with approved herbicide as needed in late June/early July.

- Poor growth of upland buffer plants – apply slow release balanced fertilizer.

Monitoring will occur regularly to measure the success of the wetland creation project and determine if the goals have been met. The following monitoring documentation will occur:

Vegetative Survival – Plant survival, species composition and vigor status will be measured in sample plots. The location of the vegetation sampling plots will be shown on the as-built planting plan. Survival of vegetation will be assessed after the first growing season, and at least once (July 1 to mid-August) in years 2, 4, and 5.

Hydrology – Hydrology will be measured by the placement of remote electronic wells to measure water depth. Hydrology will be measured once a day for at least the first year, and likely during the second year as well. If data during the first two years shows that the hydrology criteria is being met, then hydrology will be measured only once during years 4 and 5.

Wildlife – Three formal bird surveys will be conducted each monitoring season from permanent census stations throughout the mitigation site. Surveys will take place between sunrise and noon, from May through June. Biologists will conduct the survey by standing silently at a station for five minutes, followed by five minutes of recording all bird species detected by sight or sound within 30 meters of the mitigation site. In addition to the surveys, any wildlife sign (e.g. tracks, scat), and/or other sightings will be recorded during all site visits. The bird surveys will be conducted during optimal weather conditions, i.e. little or no precipitation, and light to no wind, to ensure good visibility.

Photo stations – A total of five photo stations will be located throughout the area. Each photo station will consist of a permanent marker where photographs will be taken at each compass point (N, S, E, and W) once a year in years 1, 2, 4, and 5 at the height of the growing season (July 15 to August 1).

At completion of construction an as-built plan will be prepared showing any deviations from the wetland creation plan. This can also serve as the baseline monitoring report. Monitoring reports will be prepared on a yearly basis for each monitoring year, and submitted to the appropriate regulatory agencies.

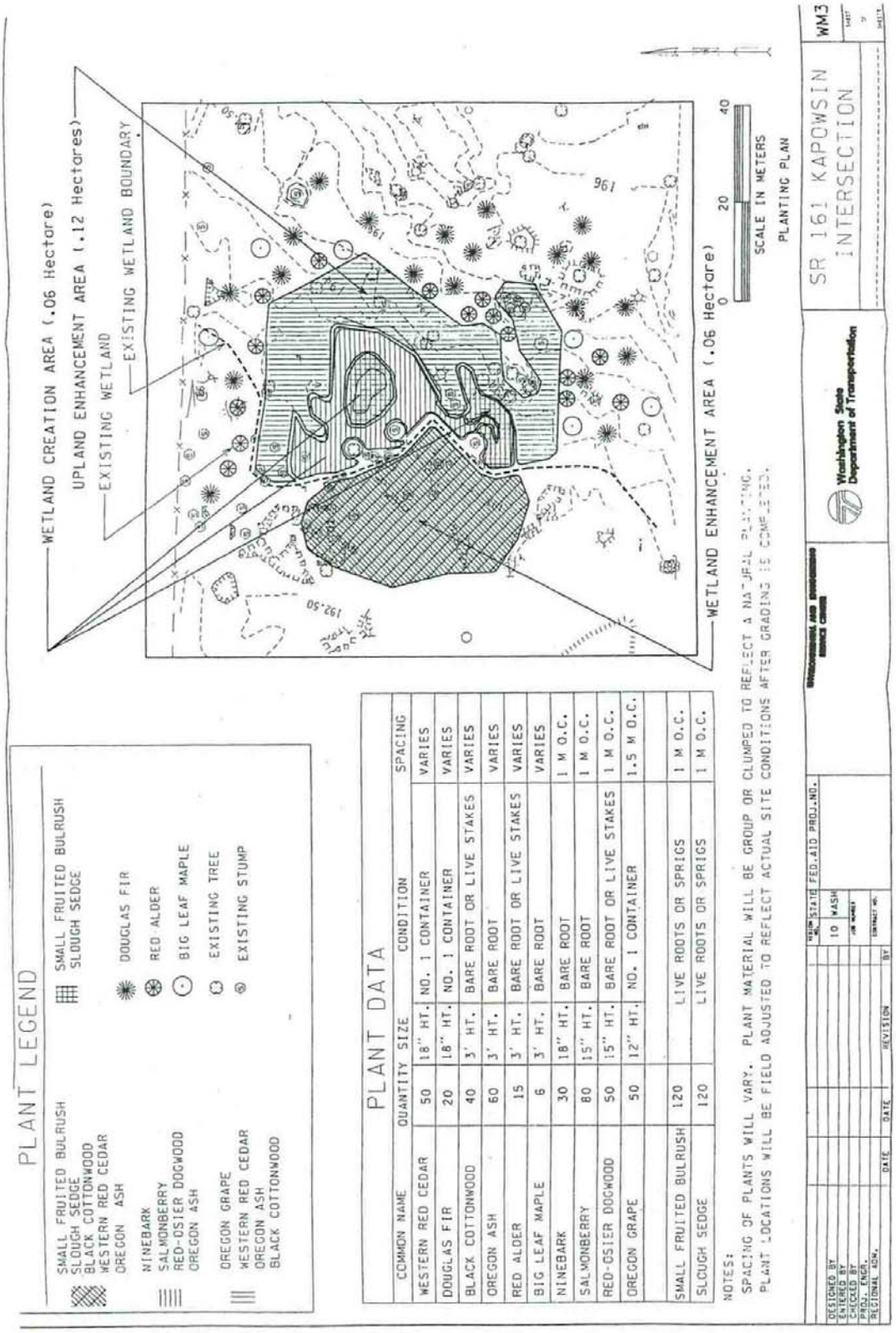
Additional monitoring to assess and address maintenance issues will be performed from May through August for the first two years. These visits will include checking for the presence of invasive plants, damage due to vandalism, drought and any other unforeseen problems. These visits are necessary so that prompt control measures can be taken.

CONTINGENCY PLAN

In the event that the goals and objectives are not met by the third year, contingency measures must be taken. These include but are not limited to replanting dead plants, hydrologic manipulation, irrigation, mulching of plants, weed control, trash removal, erosion repair, and any other practices necessary to meet the goals of the mitigation plan. Recommendations to correct deficiencies will be made after each site visit by the wetland biologist. WSDOT will correct deficiencies in a timely and responsible manner.

Appendix 5.2 – SR 161 Kapowsin Planting Plan

(Russell 1998)



COMMON NAME	QUANTITY	SIZE	CONDITION	SPACING
WESTERN RED CEDAR	50	18" HT.	NO. 1 CONTAINER	VARIES
DOUGLAS FIR	20	18" HT.	NO. 1 CONTAINER	VARIES
BLACK COTTONWOOD	40	3' HT.	BARE ROOT OR LIVE STAKES	VARIES
OREGON ASH	60	3' HT.	BARE ROOT	VARIES
RED ALDER	15	3' HT.	BARE ROOT OR LIVE STAKES	VARIES
BIG LEAF MAPLE	6	3' HT.	BARE ROOT	VARIES
NINEBARK	30	18" HT.	BARE ROOT	1 M O.C.
SALMONBERRY	80	15" HT.	BARE ROOT	1 M O.C.
RED-OSIER DOGWOOD	50	15" HT.	BARE ROOT OR LIVE STAKES	1 M O.C.
OREGON GRAPE	50	12" HT.	NO. 1 CONTAINER	1.5 M O.C.
SMALL FRUITED BULRUSH	120		LIVE ROOTS OR SPRIGS	1 M O.C.
SLOUGH SEDGE	120		LIVE ROOTS OR SPRIGS	1 M O.C.

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Photo 6.1 **Overview of the SR 509 Erdahl Ditch mitigation site from the bridge east of the site looking west. Site is to the right of the road.**

SR 509 Erdahl Ditch USACE NWP 93-4-00148

This report summarizes management and monitoring activities completed by the Washington State Department of Transportation (WSDOT) at the SR 509 Erdahl Ditch mitigation site from Fall 2003 through Fall 2004 (Photo 6.1). WSDOT Wetland Monitoring and Assessment Program activities were intended to address final year success standards. These activities include vegetation surveys, photo documentation, wetland delineation, and assessments of slope stability. Table 6.1 provides general site information and Table 6.2 summarizes this year's monitoring results.

Table 6.1 General Information for the SR 509 Erdahl Ditch Mitigation Site

USACE IP Number	93-4-00148
HPA Permit Number	93-80148-04
Township/Range/Section (impact)	T.20N/R.35E/S.2
Mitigation Location	SEC I/C SR 509 and Port of Tacoma Road, Pierce County
Construction date	1995
Monitoring Period	1996 to 2004
Year of Monitoring	9 of 9
Area of Project Impact[19]	1.27 acres
Type of Mitigation	Ditch Relocation
Area of Mitigation	0.44 acres

Table 6.2 Monitoring and Management Summary for the SR 509 Erdahl Ditch Mitigation Site

Performance Criteria	2004 Results[20]	Management Activities
Success Standard		
1. Create 0.44 acres of wetland	0.46 acres created	
2. $\geq$ 80% aerial cover of woody species in the buffer	95% ($CI_{99\%}$ = 89 - 100% cover)	Replanted in 2002
3. $\geq$ 90% aerial cover by FAC or wetter species in the wetland	93% ($CI_{90\%}$ = 84 - 100% cover)	
4. Presence of wetland-dependent species	Yes	
5. $\geq$ 90% aerial cover by vegetation in wetland	99% ($CI_{99\%}$ = 95 - 100% cover)	
6. 2:1 grade minimum and dense buffer vegetation	Present	
Permit Requirement		
Less than 10% cover of non-native invasive species	19% ($CI_{80\%}$ = 16 - 24% cover)	Weed control

[19] Two mitigation sites (SR 509 Erdahl Ditch and SR 509 Hylebos) provide compensation for impacts from the SR 509 East-West corridor project.

[20] Estimated values are presented with their corresponding statistical confidence interval. For example, 95% ($CI_{99\%}$ = 89-100%) means we are 99% confident that the true value is between 89% and 100%.

Success Standards and Sampling Objectives

Final year success standards for the SR 509 Erdahl Ditch mitigation site were excerpted from the *Wetland Mitigation Plan State Route 509 East-West Corridor* (WSDOT 1994). Companion sampling objectives follow the success standards as appropriate. Appendix 6.1 provides a complete text of the success standards and the additional permit requirement for this project and Appendix 6.2 shows the planting plan (WSDOT 1994) and photo point locations.

Success Standard 1
Wetland acreage at the Erdahl Ditch Tributary should equal or exceed 0.44 of an acre (2004).

Success Standard 2
At the end of the monitoring period, the shrub and tree planted areas of Erdahl Ditch will have a minimum of 80% average areal (*sic*) cover that is appropriate to the site and its hydrologic regime (2004).

> Sampling Objective 2
> To be 80% confident the true aerial cover of woody vegetation in the buffer is within 20% of the estimated cover value.

Success Standard 3
At the end of the monitoring period, the Erdahl Ditch Tributary wetland seeding area should have a minimum of 90% areal (*sic*) coverage of wetland species (FAC+ or wetter) (2004).

> Sampling Objective 3
> To be 80% confident the true aerial cover of FAC+ and wetter species in the wetland is within 20% of the estimated value.

Success Standard 4
Development of habitat diversity and structure will be determined by the diversity and numbers of wetland-dependent species identified during the wetland mitigation monitoring program. The sites will meet this objective if wildlife species that utilize wetlands for some or all of their habitat requirements are located (2004).

Success Standard 5
Dense vegetation establishment in the wetland (> 90% areal (*sic*) coverage) within the monitoring period (2004).

> Sampling Objective 5
> To be 80% confident the true aerial cover of herbaceous and woody vegetation in the wetland is within 20% of the estimated cover value.

Success Standard 6
Establishment within monitoring period of stable upland side slopes with a maximum 2:1 grade and dense buffer vegetation (2004).

Permit Requirement
The Erdahl Ditch Tributary replacement wetland shall include no more than 10% areal (*sic*) cover by non-native, invasive species (2004).

Sampling Objective
To be 80% confident the true aerial cover of non-native invasive species in the replacement wetland is within 20% of the estimated cover value.

Methods

A wetland delineation was conducted (Success Standard 1) using methods described in the *Washington State Wetlands Identification and Delineation Manual* (Ecology 1997). A Global Positioning System (Trimble TSCI data logger) was used to determine the wetland area.

To evaluate aerial cover of woody and herbaceous vegetation, 24 temporary transects were placed perpendicular to a baseline using a systematic random sampling method (Figure 6.1).

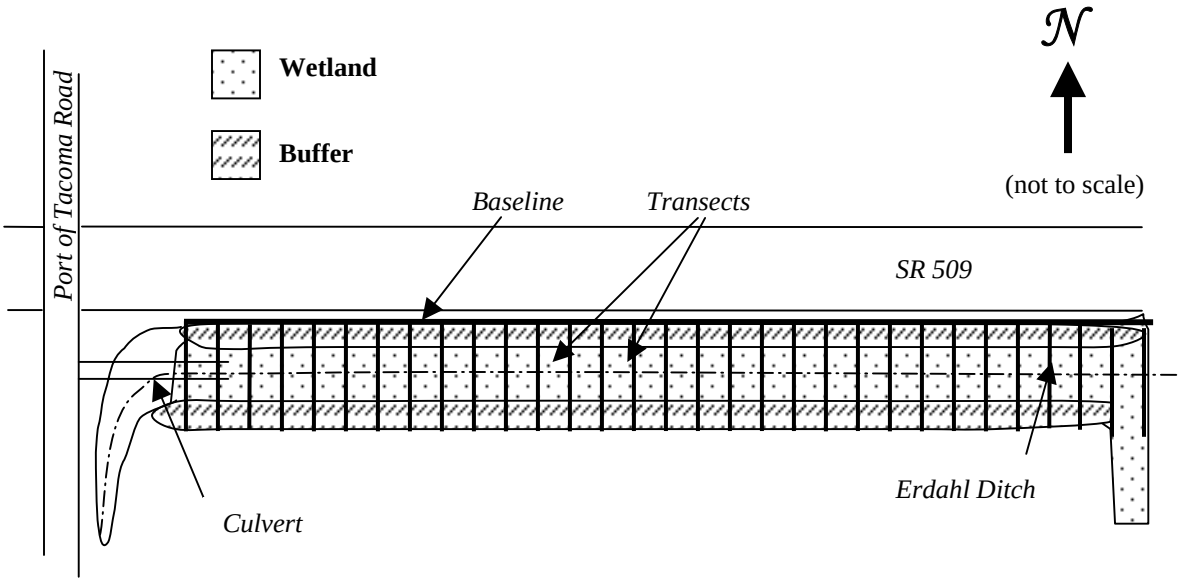

Figure 6.1 SR 509 Erdahl Ditch Mitigation Site Sampling Design (2004)

Aerial cover of vegetation in the wetland (Success Standards 3 and 5) was addressed using the line-intercept method because of the lack of herbaceous vegetation. Twenty-

four 5-meter line-segment sample units were randomly located along the sampling transects.

To address Success Standards 2 and 6, tree and shrub species cover data were also collected using the line-intercept method in the buffer area. Twenty-four 10-meter line-segment sample units were positioned in the upland buffer.

Non-native invasive species cover was assessed using the point-intercept method. Twenty-four 15-meter point-line sample units (60 points each) were used to evaluate this attribute. Sample units were randomly located along each of the above sampling transects (Permit Requirement).

Sample size analysis confirmed that sufficient sampling had been completed based on the sampling objectives and the desired level of statistical confidence. The following sample size equation was used to perform this analysis.

$$n = \frac{(z)^2 (s)^2}{(B)^2}$$

z = standard normal deviate
s = sample standard deviation
B = precision level[21]
n = unadjusted sample size

To address the development of habitat diversity and structure, point-count bird surveys were coupled with incidental wildlife observations over the nine-year monitoring period (Success Standard 4).

A clinometer was used to determine the grade of the side slopes (Success Standard 6).

For additional details on the methods described above, see the Methods section of this report or view WSDOT Wetland Mitigation Site Monitoring Methods at: http://www.wsdot.wa.gov/environment/biology/docs/MethodsWhitePaper052004.pdf

Results and Discussion

Site development achieved the intended outcome in one of two general functional categories (wildlife habitat and water quality improvement) and provided several functions not envisioned. Dense woody vegetation development in the buffer provides refuge for birds and other wildlife. The site was also designed to provide water quality treatment with established dense stands of vegetation to help attenuate flows and provide sediment-trapping capability. A closed canopy formed over the ditch and shaded out most of the original herbaceous vegetation. This has likely diminished the planned functions of water quality treatment and sediment trapping. However, the unexpected

[21] The precision level equals half the maximum acceptable confidence interval width multiplied by the sample mean.

woody vegetation development on site contributes the following functions: production and export of organic material, shade to reduce exiting water temperatures, and a future source of large woody debris.

Success Standard 1 – Wetland Acreage Should Equal or Exceed 0.44 of an Acre.
The delineated wetland area was determined to be 0.46 acres, exceeding the project mitigation obligation of 0.44 acres (WSDOT 1994).

Success Standard 2 – At least 80% Aerial Cover of Woody Species in the Buffer
Woody species in the buffer provide an estimated 95% ($CI_{99\%}$ = 89 - 100%) aerial cover. This exceeds the requirement of 80% cover in 2004. Overall, the buffer has developed as intended (See Photo 6.2) (Success Standard 2 and 6).

Photo 6.2 SR 509 Erdahl Ditch Buffer (August 2004)

Success Standard 3 – 90% Aerial Cover by FAC+ and Wetter Species in the Wetland
Despite low cover of herbaceous plants, cover by wetland woody species was still very high. The aerial cover of native species in the wetland is estimated to be 93% ($CI_{90\%}$ = 84 - 100%). This exceeds the 90% aerial cover requirement. *Salix lucida* (Pacific willow) provides the majority of this cover.

Success Standard 4 – Presence of Wetland-Dependent Wildlife & Structural Diversity
A number of wildlife species have been observed on site during the monitoring period. Three of the 29 bird species observed on site were wetland-dependent and two were wetland-associated (Table 6.3). In addition, Song Sparrows (*Melospiza melodia*) and Downy Woodpeckers (*Picoides pubescens*) were observed nesting in the wetland areas. Pacific chorus frogs (*Pseudacris regilla*) were also observed in the wetland.

The following woody species observed on site are a source of fruit or seeds for birds and other wildlife: *Mahonia aquifolium* (tall Oregon grape), *Cornus sericea* (redosier dogwood), *Salix* species (willows), and *Symphoricarpos albus* (snowberry) (Cooke 1997). Herbaceous species, shrubs (2 meters high) and trees (6-8 meters high) create structural diversity. These observations indicate that the site provides habitat for wildlife, including several wetland-dependent bird and amphibian species.

Table 6.3 SR 509 Erdahl Ditch Mitigation Site Observed Bird Status (1996-2004)

Common Name	Scientific Name	Status[22]
Barn Swallow	*Hirundo rustica*	Wetland-associated
Willow Flycatcher	*Empidonax traillii*	Wetland-associated
Common Yellowthroat	*Geothlypis trichas*	Wetland-dependent
Great Blue Heron	*Ardea herodias*	Wetland-dependent
Red-Winged Blackbird	*Agelaius phoeniceus*	Wetland-dependent

Success Standard 5 – At least 90% Aerial Cover by Vegetation in the Wetland
The total aerial cover of plants (herbaceous and woody) in the wetland was estimated to be 99% ($CI_{99\%}$ = 95 - 100%) cover. This exceeds the 90% cover requirement, therefore meeting Success Standard 5.

Success Standard 6 – Establish Stable Upland Side Slopes with a Maximum 2:1 Grade
Clinometer readings obtained in 1998 indicate that the maximum 2:1 grade requirement for side slopes was not exceeded. Observations each year indicate that the densely vegetated slopes are stable and erosion has not occurred on site.

Permit Requirement – No More Than 10% Aerial Cover by Non-Native Invasive Species
Despite an ongoing annual weed control program (see Table 6.4), cover of non-native invasive species exceeds the threshold with an estimated cover value of 19% ($CI_{80\%}$ = 16 - 24%). This year, 7 non-native invasive species were observed on site. *Rubus armeniacus* (Himalayan blackberry) is the most prominent of these species present. *Polygonum cuspidatum* (Japanese knotweed) is encroaching from a private residence along the south side of the site. *Convolvulus arvensis* (field bindweed), *P. arundinacea* (reed canarygrass), *Rubus laciniatus* (cutleaf blackberry), *Cirsium vulgare* (bull thistle), and *Geranium robertianum* (stinky Bob) are present at trace levels. *Phragmites australis* (common reed) seems to have been successfully controlled, and weed control for other species is ongoing.

Table 6.4 Management Activity Summary for the SR 509 Erdahl Ditch Mitigation Site

Date	Adaptive Management
Fall 2004	Invasive species control- mechanical methods and herbicide application.
Summer 2002	Weed control.
2002	Invasive species control- mechanical methods and herbicide application.
2001	Invasive species control- mechanical methods and herbicide application.

[22] Birds are assigned upland or wetland-dependent species status based on the classification scheme presented in Brown and Smith (1998). Regional variation occurs. Additional references used to further classify bird species include Thomas (1979), Ehrlich et al. (1998), and Smith et al. (1997).

Appendix 6.1 – SR 509 Erdahl Ditch Success Standards

The following excerpt is from the *Wetland Mitigation Plan State Route 509 East-West Corridor* (WSDOT 1994). This mitigation plan applies to both the SR 509 Erdahl Ditch and SR 509 Hylebos Creek mitigation sites. The standards addressed this year are identified in **bold** font. The monitoring period for the SR 509 Hylebos site has been extended through 2005. It was monitored informally this year and will be formally monitored in 2005.

Goals, Objectives, and Standards of Success

The mitigation package for these sites has several broad-based goals. First is the creation of the physical environment necessary to support and promote the development of wetland characteristics. The second goal is to establish wetland functions and values that either will be lost due to construction of the roadway or are limited in the region due to past practices. The most important of these functions and values include water quality treatment and habitat.

The wetland mitigation plan will create and enhance the general wetland functional values at the sites. General functional categories and the anticipated values attributable to these categories as a result of the mitigation project are as follows.

Wildlife:

These wetland areas should provide some habitat for wildlife species, principally birds and small mammals. None of the sites, because of their locations in an urban setting will be suitable for large mammals except for possible transient usage. The plant species selected will provide a food resource for wildlife species.

The wetlands will be suitable for some species of amphibians. The Hylebos site, because of its connection to the creek, will be of some value to fisheries.

Hydrology/Water quality

Water quality functions are the most important function of the existing wetlands within the corridor. The mitigation plan is primarily designed to replace any lost water quality treatment values resulting from the fills. The mitigation for the railroad pond should actually improve the water quality function over the existing pond value. **Dense stands of vegetation will be established to facilitate the treatment of water within the wetlands. The vegetation will help attenuate flows and provide sediment trapping capability.**

Human values:

The development of wetlands on these sites by WSDOT will preclude the use of these areas for its current economic value (industrial and commercial use). Public access will not be available at these sites and there will be no way for the public to access the wetlands from the road.

Objective #1:
Construct the mitigation sites concurrently with roadway construction with completion no later than one year after project construction. If possible, the contractor should schedule the mitigation as one of the first tasks.

Success Criteria:
Completion as per objective.

Objective #2:
Increase the acreage of wetlands in the Tacoma tide flat region.

Success Criteria:
Following five years of development and growth, the created wetland acreage within the mitigation sites, as delineated using the 1987 Corps manual, should exceed the acreage of the impacted wetlands.

Wetland acreage at the Blair Ditch (Erdahl Ditch)Tributary should equal or exceed 0.44 of an acre.

Wetland acreage at the Hylebos mitigation site should equal or exceed 1.93 acres.

Objective #3:
Establish wetland and upland vegetation composition with appropriate structure.

Success Criteria:
At the end of the third year following the construction of the mitigation sites, aerial coverage shall exceed 50%.

At the end of the monitoring period, (5 years) the shrub and tree planted areas of Blair Ditch (Erdahl Ditch) and Hylebos sites will have a minimum of 80% average areal that are appropriate to the sites and to its hydrologic regime.

At the end of the monitoring period, the Blair Ditch (Erdahl Ditch) Tributary wetland seeding area should have a minimum of 90% areal coverage of wetland species (FAC+ or wetter).

The Hylebos mitigation site Lyngby's sedge planting area should have 50% areal coverage of native wetland species at the end of the monitoring period.

Objective #4:
The wetland mitigation sites should provide wildlife habitat.

Success Criteria:
Development of habitat diversity and structure will be determined by the diversity and numbers of wetland dependent species identified during the wetland mitigation

monitoring program. The sites will meet this objective if wildlife species that utilize wetlands for some or all of their habitat requirements are located.

Objective #5:
Creation of conditions in the Blair Ditch (Erdahl Ditch) Tributary for water quality treatment that enhances it for this function.

Success Criteria
Dense vegetation establishment in the wetland (≥90% areal coverage) within the monitoring period.

Establishment within monitoring period of stable upland side slopes with a maximum 2:1 grade and dense buffer vegetation (greater than 80% areal coverage).

Objective #6:
Limit potential for contamination from the former UST site located at the Hylebos mitigation site.

Success Criteria:
Containment and removal of any contaminated soils found during grading activities at the Hylebos mitigation site.

The Hylebos mitigation site and the relocated Erdahl Ditch tributary will be owned and protected in perpetuity by WSDOT.

ADDITIONAL PERMIT REQUIREMENTS

The following excerpt is from the *United States Army Corps of Engineers Individual Permit Number 93-4-00148* (USACE 1994). The permit requirement addressed this year is identified in **bold** font.

At the end of the monitoring period, the 90% areal cover of dense vegetation to be established in the Blair ditch (Erdahl Ditch) Tributary replacement wetland and the Hylebos Creek mitigation wetland shall include no more than 10% areal cover by non-native, invasive species.

Appendix 6.2 – SR 509 Erdahl Ditch Planting Plan
(WSDOT 1994)

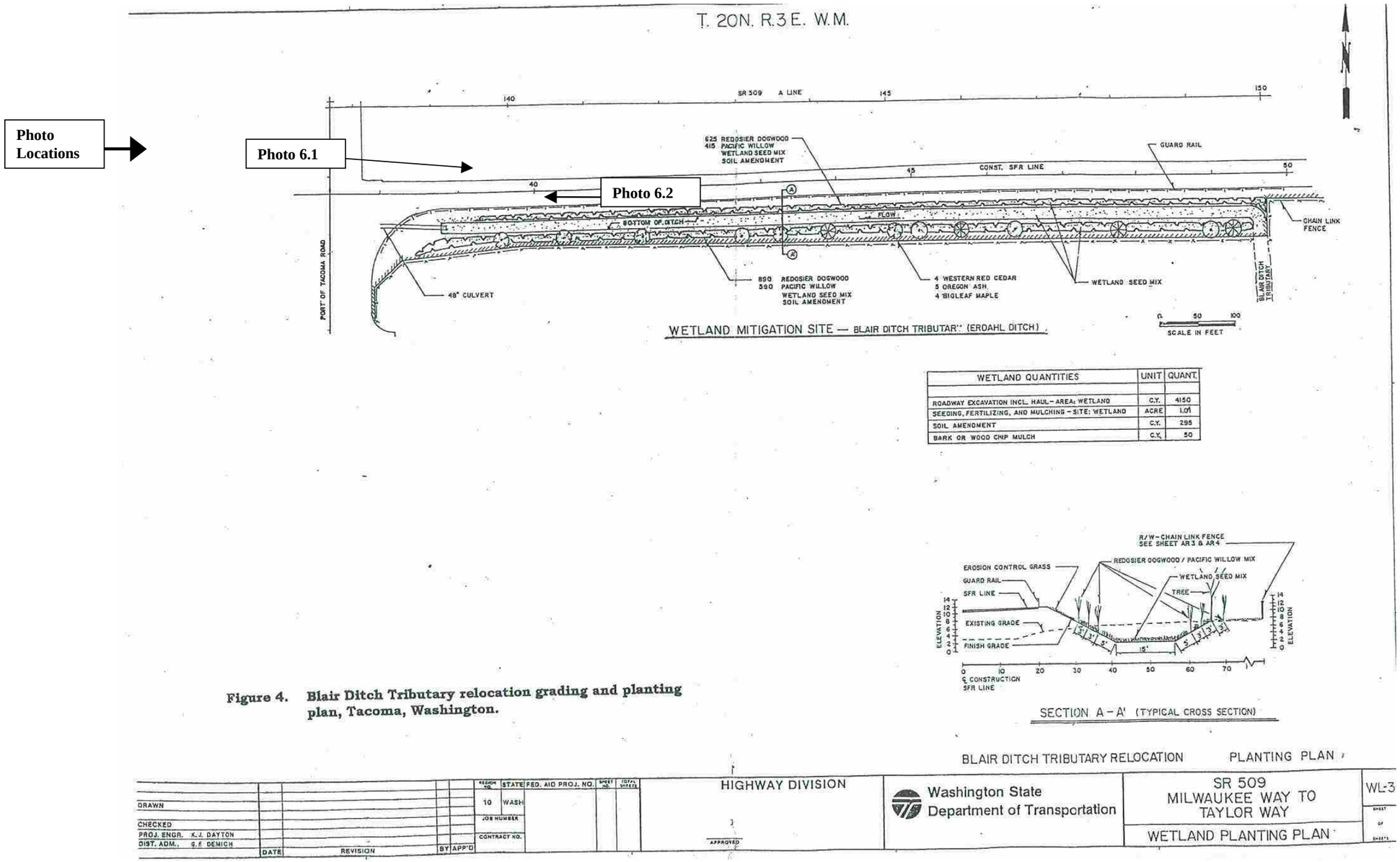

Figure 4. Blair Ditch Tributary relocation grading and planting plan, Tacoma, Washington.

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Glossary of Terms

Abundance (total) – the total number of individuals, cover, frequency of occurrence, volume, or biomass of a species, or group of species, within a given area.

Accuracy – the closeness of a measured or computed value to its true value.

Adaptive management – the process of linking ecological management within a learning framework (Elzinga et al. 1998).

Aerial cover – is the percent of ground surface covered by vegetation of a particular species (or suite of species) when viewed from above (Elzinga et al. 1998). Values for aerial cover are typically obtained from point-line, point-frame, or line-intercept data. Aerial cover does not include overlapping cover of separate plants, thus it does not exceed 100%.

Areal estimates – are made using the known boundary of a feature or statistical population. Areal estimates are often expressed in units of area.

Aquatic vegetation – includes submerged and rooted (*Elodea, Myriophyllum*) or floating (non-rooted) plants (*Lemna, Azolla, Wolfia*). For compliance purposes, these plants are not included in cover estimates. Vascular, rooted, floating-leaved plants *are* included in cover estimates (e.g., *Nuphar, Potamogeton*).

Bare ground – an area that can support, but does not presently support vascular vegetation.

Community – a group of populations of species living together in a given place and time.

Confidence interval (CI) – is an estimate of precision around a sample mean. A confidence interval includes confidence level and confidence interval half-width.

Density – the number of plants per unit area (typically square meters).

Densitometer – a hollow T-shaped polyvinyl chloride (PVC) device that includes horizontal and vertical leveling and a mirror to locate a precise vertical point in space either directly above or directly below the densitometer. Target vegetation intersecting the vertical line of sight through the instrument is recorded.

FAC/Facultative – 1) Biological Definition: capable of adaptive response to varying environments (i.e., presence or absence of oxygen). 2) USFWS Indicator Status: Equally likely to occur in wetlands or in non-wetlands (estimated probability 34%-66%) (Reed 1988).

FACU/Facultative Upland – USFWS Indicator Status: Usually occur in non-wetlands (estimated probability 1% to 33%), but occasionally occur in wetlands (Reed 1988).

FACW/Facultative Wetland – USFWS Indicator Status: Usually occurs in wetlands (estimated probability 67%-99%), but occasionally occur in non-wetlands (Reed 1988).

Herbaceous – with characteristics of an herb; an annual, biennial, or perennial plant that is leaflike in color or texture, and not woody.

Hydric soils – soils formed under the conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register 1994).

Invasive – a plant that interferes with management objectives on a specific site at a specific point in time (Whitson et al. 2001). For monitoring purposes, invasive species include those listed on the current County Noxious Weed List, and on a site-by-site basis, other species may be included (such as *Rubus armeniacus* (Himalayan blackberry)).

Line-segment – a linear sample unit that is used to measure vegetative cover.

Macroplot – usually refers to a relatively large sampling area in which sub-sampling will be conducted, often using quadrats, line-segments or point-lines (Elzinga et al. 1998).

Obligate Upland - USFWS Indicator Status: Occur almost always in non-wetlands (estimated probability >99%) under natural conditions in the region specified. If a species does not occur in wetlands in any region, it may not be on the National List, and is designated Not Listed (NL) (Reed 1988).

OBL/Obligate Wetland - USFWS Indicator Status: Occur almost always in wetlands (estimated probability >99%) under natural conditions (Reed 1988).

Open water – an area intended to be non-vegetated and permanently inundated as described in the site mitigation or planting plan.

Point-frame – is a square or rectangular quadrat that consists of a set of identified points used to collect vegetation data.

Point-Intercept Device – a tripod that supports a rod that can be leveled and lowered vertically to intercept target vegetation at an identified point.

Point-line – linear series of points comprising a sample unit.

Point-quadrat (points) – a single point, used to sample vegetation data. The point quadrat is theoretically dimensionless.

Population (biological) – all individuals of one or more species within a specific area at a particular time.

Population (statistical) – the complete set of individual objects (sampling units) about which inferences are made.

Precision – the closeness of repeated measurements of the same value.

Quadrat – an area delimited for sampling flora or fauna; the sampling frame itself.

Random sampling – sampling units drawn randomly from the population of interest.

Relative abundance (birds) – the number of individuals per unit of sampling effort.

Relative cover – the relative cover of a plant species (or suite of species) is the proportion of the target species coverage compared to that of all species in the plant community combined (Brower et al. 1998).

Restricted random sampling method – a sampling method that divides the population of interest into equal-sized segments. In each segment, a single sampling unit is randomly positioned. Sampling units are then analyzed as if they were part of a simple random sample (Elzinga et al. 1998).

Sample – a subset of the total possible number of sampling units in a statistical population.

Sample size equations – use sample mean and standard deviation to determine if data have been collected from enough sample units to meet the sampling objectives.

Sample standard deviation – a value indicating how similar each individual observation is to the sample mean.

Sampling – the act or process of selecting a part of something with the intent of showing the quality, style, or nature of the whole.

Sampling objective – a clearly articulated goal for the measurement of an ecological condition or change value (Elzinga et al. 1998). Sampling objectives provide a complement to success standards and describe the desired level of precision for sampling. Elements of a sampling objective include the desired confidence level and confidence interval half-width, or the acceptable false-change error and acceptable missed-change error level.

Sampling units – the individual objects that collectively make up a statistical population.

Standard deviation – a measure of how similar each individual observation is to the overall mean value.

Shrub – a woody plant that at maturity is usually less than six meters (20 feet) tall and generally exhibits several erect, spreading, or prostrate stems and has a bushy appearance (Cowardin et al. 1979). The species categories in this report follow Cooke (1997).

Species richness – the total number of species observed on a site.

Structures – any structure that is not expected to support vegetation during the monitoring period. Structures may include habitat structures, rocks, and other artifacts.

Stratified random sampling method – the population of interest is divided into two or more groups (strata) prior to sampling. Within each stratum the sample units are the same. Sample units from different strata may or may not be identical. Random samples are obtained within each group (Elzinga et al. 1998).

Systematic random sampling method – the regular placement of quadrats, points, or lines along a sampling transect following a random start.

Transect – for vegetation surveys, the transect is a line used to assist in the location sample units (point-lines, quadrats, line-segments or frames) across the monitoring study area.

Tree – a woody plant that at maturity is usually six meters (20 feet) or more in height and generally has a single trunk, unbranched for one meter or more above ground, and more or less definite crown (Cowardin et al. 1979). The species categories in this report follow Cooke (1997).

Vegetation structure – the physical or structural description of the plant community (e.g. the relative biomass in canopy layers), generally independent of particular species composition.

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